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AERODYNAMIC CHARACTERISTICS OF A BLUNT HALF-CONE ENTRY CONFIGURATION AT MACH NUMBERS OF 5.2, 7.4, AND 10.4

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AERODYNAMIC CHARACTERISTICS OF A BLUNT HALF-CONE ENTRY CONFIGURATION AT MACH NUMBERS OF 5.2, 7.4, AND 10.4*

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SUMMARY

An investigation has been conducted with a blunt, 30° half-cone entry configuration, known as the M-1, to evaluate its aerodynamic force, stability, and control characteristics at Mach numbers of 5.2, 7.4, and 10.4 and at Reynolds numbers of 400,000 to 1,200,000 based on the body length.

In agreement with results determined previously from extensive investigations of the M-1 shape, the basic body was self-trimming at a lift-drag ratio of about 0.5, was statically stable about all three axes, and could be trimmed over a range of lift-drag ratios from 0.5 to 0 with aerodynamic-control systems. Theoretical estimates, primarily based on impact theory, were satisfactory for approximating the aerodynamic characteristics of the basic body without flaps or with flaps at small deflections. A new type of roll control was investigated and found to be more effective than aerodynamic roll controls previously tested with the M-1 by a factor of about two. A change in body shape representative of that which might occur as a result of ablation during entry flight was found to have a small effect on the aerodynamic characteristics. For large flap deflections, shadowgraphs indicated unsteady flow in the region where the body and flap shock waves coalesce, and qualitative tests utilizing heat-sensitive paint indicated localized hot spots on the flaps and the body ahead of the flaps for the same large flap deflections.

INTRODUCTION

It is now well known that a body with controlled lifting characteristics has several important advantages over a ballistic body for use as a manned atmosphere-entry vehicle. Studies, such as reference 1, have shown that the ability to develop lift-drag ratios of about 0.5, can significantly reduce maximum heating rate and deceleration and increase range and maneuverability during entry. Reference 2 indicates that a vehicle with this lift-drag ratio has less stringent guidance requirements because its parabolic-speed entry corridor is five times deeper than that for a ballistic vehicle. To realize the potential advantages of a lifting body, a control system is required to vary the lift-drag ratio and the roll angle.

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One possible lifting-type body consisting basically of one-half of a blunt cone with a semiapex angle of 30° and flaps at the base for control (now known as the M-1) was suggested in reference 1 and was shown to be stable and self-trimming at a maximum lift-drag ratio of 0.5 at hypersonic speeds without the use of aerodynamic control. Additional studies of this configuration are presented in references 3 through 11. A review of the force data presented in references 6 through 10 indicated some areas where further research was necessary. For example, a complete aerodynamic control system capable of providing direct roll control free of cross-coupling problems had not been developed, nor was the effect of Reynolds number and Mach number changes defined above Mach number 6 except in helium. Also reference 6 indicated a loss in stability with a slight change in nose profile which suggested further study of a possible effect of an ablated surface on stability.

The present investigation was undertaken to extend the prior investigations and to support the data obtained in helium. Two sets of controls previously tested were included in the analysis. The first set, which consisted of two upper and two lower pitch flaps, was only briefly tested because of its aerodynamic cross coupling. The second control set consisted of single upper and lower pitch flaps and two side flaps for directional control. This second control set, with the side flaps modified to provide roll control, is emphasized herein. Comparison of the experimental data with estimates made using a combination of impact theory and two-dimensional shock-expansion theory is presented to permit a further evaluation of the theory.

NOTATION

A base area of model, $0.5686\ d^2$

C_A axial-force coefficient

C_{A_b} base-force coefficient, $C_{p_b} \cos 6.6^{\circ}$

C_D drag coefficient, $\frac{\text{drag}}{q_{\infty}A}$

C_L lift coefficient, $\frac{\text{lift}}{q_{\infty}A}$

C_l rolling-moment coefficient, $\frac{\text{rolling moment}}{q_{\infty}Ad}$

C_m pitching-moment coefficient, $\frac{\text{pitching moment}}{q_{\infty}Al}$

C_n yawing-moment coefficient, $\frac{\text{yawing moment}}{q_{\infty}Ad}$

C_N normal-force coefficient, $\frac{\text{normal force}}{q_\infty A}$

C_p pressure coefficient, $\frac{P-P_\infty}{q_\infty}$

C_{p_b} base-pressure coefficient, $\frac{P_b-P_\infty}{q_\infty}$

C_Y side-force coefficient, $\frac{\text{side force}}{q_\infty A}$

c.g. center of gravity and reference for moments

d base diameter of model

l length of model

L/D lift-drag ratio

M Mach number

P static pressure

P_∞ free-stream static pressure

q_∞ free-stream dynamic pressure

R Reynolds number based on model length

T_{t_1} reservoir total temperature

α angle of attack (measured with respect to basic-body upper surface)

β angle of sideslip

Δ incremental change due to control deflection

δ_l [1]deflection angle of a lower flap

δ_r [1]deflection angle of roll portion of a side flap (relative to yaw segment)

δ_u [1]deflection angle of an upper flap

δ_y [1]deflection angle of a side flap

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[1]Unless otherwise indicated, at zero deflection, control is normal to body base and positive deflections are outward into air stream (see fig. 4(b)).

Subscripts

α	derivative with respect to angle of attack
β	derivative with respect to angle of sideslip
L	left side looking upstream
R	right side looking upstream
S	stability axis
max	maximum value

APPARATUS AND MODELS

The Ames 3.5-Foot Hypersonic Wind Tunnel is a blowdown type capable of operating at nominal Mach numbers of 5, 7, 10, and 15, at total pressures up to 1,800 pounds per square inch, and at stagnation temperatures up to 3,800° F for testing times up to four minutes. A schematic sketch of the tunnel system and a photograph of the test section and model support system are shown in figures 1 and 2. The helium line indicated in figure 1 supplies helium to a film-cooling system which protects the nozzle and test section walls from the hot free-stream air. The helium is injected through an annular slot located just upstream of the minimum area section of the nozzle. The axially symmetric test section has a nominal diameter of 3.5 feet. The model support system is hydraulically actuated and servo controlled over an angle-of-attack range of -5° to +15°. Other angles in the pitch or yaw planes are obtained with changes in position or mounting of the models. The operation of the wind tunnel is automatic during a test run; the model attitude sequence and pressures desired are programmed into a controller prior to a run. The data are recorded on magnetic tape at a rate of 2,500 samples per second.

The models are mounted on a conventional strain-gage balance that is thermally protected by an evacuated steel bottle. The bodies and flaps were made of a stainless steel which has good strength characteristics at elevated temperatures. The flaps were solid but the bodies had a wall thickness of 3/8 inch except for the nose which was 2 inches thick.

The dimensions of the half-cone entry body (basic M-1 shape) are presented in figure 3. The blunt nose profile was faired from a spherical shape to a cone, as shown by the listed ordinates and described in reference 6 as the modified profile. Two control sets were tested with the M-1: Control set I consisted of two upper and two lower pitch flaps (fig. 4(a)); control set II consisted of single upper and lower pitch flaps with two side flaps for directional control (fig. 4(b)). Photographs of the basic body and the control systems with the flaps deflected are shown in figure 5. For these tests the side flaps of control set II were modified to provide roll control. The modification consisted of folding either an upper or a lower corner of the flap as shown in figures 4(b) and 5(b).

A second body was made and tested with a profile that differed from the basic shape by an amount representative of the material lost during ablation. The dimensions of this body, which is 0.1 inch shorter than the basic body, are presented in figure 6. The amount and distribution of material removed from the basic shape was determined from an analysis of an earth atmosphere entry of a possible three-man lunar vehicle. A brief description of this analysis is included in the discussion of the results obtained for the ablated body.

TESTS AND PROCEDURES

The tests were conducted at Mach numbers of 5.2, 7.4, and 10.4 at angles of attack from -30° to $+15^\circ$, and at Reynolds numbers from 400,000 to 1,200,000 based on the body length. The data were recorded automatically at each of 19 angle-of-attack positions during an average total testing time of about 1-1/3 minutes. To insure that the angle of attack was stationary at each position before data were taken, the angle of attack was automatically monitored and data were taken only when conditions were steady. To cover the desired angle-of-attack range of -30° to $+15^\circ$, three separate runs were necessary. Data at angles of attack from -5° to $+15^\circ$ were taken with the model erect, and data at $+5^\circ$ to -15° and -10° to -30° (model base-plate angle, -15°) were taken with the model inverted.

All aerodynamic coefficients are referred to the base area and to an assumed center of gravity as shown in figures 3 and 4(a); the pitching-moment coefficients are referred to the basic-body length and yawing- and rolling-moment coefficients to the basic-body diameter. The experimental and theoretical data contain the small drag contribution of the body base. Theoretical estimates of the aerodynamic characteristics are based on impact theory similar to that presented in reference 12, except for the upper surface of the body where two-dimensional shock-expansion theory was used and for the base-drag coefficient which was assumed proportional to $1/M^2$. Estimates were also made for which the impact-theory portion was modified by using the computed total-pressure coefficient downstream of a normal shock wave rather than the value of 2.00.

The models were coated with paints which vary in color with temperature as described in reference 13. These paints were used to indicate hot spots on the body and flaps. Photographs of the hot spots were then correlated with shadowgraph pictures.

In addition to the tests in the 3.5-foot tunnel, a few tests were conducted in the Ames 14-inch helium tunnel at Mach numbers of 10.9, 17.8, and 21.2. These tests were similar to those described in reference 10.

PRECISION

The model attitudes could be repeated with errors well within $\pm 0.1^\circ$; however, stream-angle corrections (maximum angularity is 0.3°) have not been made. The estimated maximum errors in the data that could result from instrumentation and/or data-recording errors for the test ranges of Mach number, Reynolds number, and reservoir stagnation temperature are listed in the following table:

M	R	T_{t_1}, °F	C_D	C_L	C_Y	C_m	C_n	C_l
5.2	800,000[1]	1450 to 1500 ±30	±0.001	±0.003	±0.002	±0.0016	±0.0005	±0.0004
7.3 to 7.5	400,000	800 to 900 ±30	±.007	±.024	±.014	±.0111	±.0037	±.0027
7.3 to 7.5	800,000	750 to 800 ±30	±.004	±.014	±.008	±.0064	±.0022	±.0015
7.3 to 7.5	800,000[1]	1500 to 1600 ±30	±.002	±.006	±.004	±.0028	±.0009	±.0007
7.3 to 7.5	1,200,000	800 to 850 ±30	±.003	±.009	±.005	±.0042	±.0014	±.0010
10.4	400,000	1550 to 1700 ±50	±.006	±.021	±.013	±.0101	±.0034	±.0024
10.4	600,000[1]	1600 to 1800 ±50	±.004	±.015	±.009	±.0068	±.0023	±.0016

[1]The majority of the data were taken at these conditions.

An additional error of about 1 percent is possible from the variation in dynamic pressure. In general, the data repeated for one set of test conditions with differences less than the errors stated.

RESULTS AND DISCUSSION

Presentation of Results

The experimental data as a function of model attitudes and/or control deflections are presented first for the basic and ablated bodies and then for the basic body with various control configurations. The aerodynamic characteristics of the basic body, including the effect of ablation are shown in figures 7 through 10. The Reynolds numbers of the tests as a function of Mach number are shown in figure 11. Selected data for control set I are presented in figure 12; otherwise the data presented for control set I are limited to later comparisons with control set II and to Mach number cross plots. Emphasis was placed on the investigation of control set II modified to include roll control, and these results are presented in figures 13 through 27. Table I lists the aerodynamic characteristics for the basic body with side flaps undeflected and includes representative base-drag coefficients in parts (e) and (f). Impact theory has been used to compute the characteristics of every configuration, and where convenient, these estimates are presented in each figure with the experimental results.

Unless otherwise noted the results are for Reynolds numbers of 800,000 at $M = 5.2$ and 7.4, and 600,000 at $M = 10.4$ (based on the length of the body). As will be discussed with the results for control set II, the effects of Reynolds number changes of this order were negligible, and therefore the Reynolds numbers are not listed on each figure.

Basic Body

Longitudinal characteristics.- The experimental results of figure 7 demonstrate that the basic body without controls will trim at a lift-drag ratio of about 0.5 and is statically stable for the selected center-of-gravity location. In addition, the theoretical estimates in figure 7 are in approximate agreement with the experimental trends with angle of attack. These results support the findings of references 6 and 10. It should be noted that the contribution of base drag is included in all data presented in this report. Representative agreement between the estimated and experimental base-pressure coefficients for the basic body is shown in figure 8.

Lateral-directional characteristics.- As shown in figure 9, the lateral- and directional-stability characteristics of the basic body indicate it to be stable for the test angles of attack. These characteristics are insensitive to changes in angle of attack from -5° to $+15^{\circ}$ as indicated by both experimental and theoretical results in figure 9(a). These experimental results were generally determined from a two-point slope of data obtained at sideslip angles of 0° and -5°. The slopes at zero angle of attack and the linearity of the data at small angles of sideslip were verified by results obtained for $\beta = -15^{\circ}$ to $+5^{\circ}$ as shown in figure 9(b).

Effects of ablation.- As mentioned previously, this phase of the investigation was undertaken because the data of reference 6 indicated a decrease in longitudinal stability with a small change in nose profile for the basic body with control set I undeflected. In the present study, tests were made with the body contour modified as shown in figure 6 to simulate a change in shape due to ablation. The amount of material ablated was determined from calculations for three types of entry into the earth's atmosphere, as defined in figure 11, a satellite entry, an overshoot parabolic entry, and an undershoot parabolic entry, and for four different plastic ablators with densities from 59 to 150 pounds per cubic foot. For this range of conditions, the maximum thickness of material removed from the stagnation point, scaled to model size, varied between 0.090 and 0.113 inch. A value of 0.100 inch was selected for the test. Away from the stagnation point, the material removed was assumed to vary directly with the distribution of the heat-transfer rates of reference 11.

The effects of the shape change of the present investigation, which is less localized than that of reference 6, were very slight (fig 10) for the basic body with control set II undeflected ($M = 10.4$). Estimates based on impact theory also indicated only a slight effect of the shape change. Although not presented, similar results were obtained at $M = 7.4$ with control set I undeflected. The slight increase in stability due to the shape change (fig. 10) is of the same magnitude as a computed decrease in stability which would result from a movement of the center of gravity as material is ablated from the flight vehicle. The computed vertical movement of the center of gravity was slightly stabilizing, but was small relative to the computed destabilizing longitudinal movement. For this estimate, it was assumed that the full-scale vehicle had a 12-foot base diameter and an ablation-material weight of 75 pounds per cubic foot.

Control Set II

Longitudinal characteristics.- Control set II consisted of single upper and lower pitch flaps with two side flaps for directional and roll control. Representative effects of Reynolds number changes on the longitudinal aerodynamic characteristics of the basic body with the upper flap of control set II deflected 90° are shown in figure 15. The drag and pitching-moment coefficients increased only slightly with increased Reynolds number. The effects for the example shown are equal to or greater than the effects of Reynolds number noted for any other test configuration.

Incremental changes in the pitching-moment coefficients with changes in flap angle and in angle of attack are shown in figure 16 for Mach numbers of 7.4 and 10.4. The lift- and drag-coefficient increments for $M = 7.4$ shown in figure 16(b) are typical of those for both Mach numbers. The results of figure 16 are plotted as a function of the flap angle relative to the free stream to permit a more direct comparison of the upper and lower pitch flaps. The upper flap was generally less effective than the lower flap. The effects of interference from the body are indicated in figure 16 by the differences between the experimental results and theoretical estimates. For example, the lower flap at large deflections and at moderate angles of attack was more effective than indicated by the theoretical estimates. This increased effectiveness is considered to be due to increased pressures primarily on the flap produced by a multiple compression through the body and flap shock waves as previously discussed in reference 6. (See also the shadowgraph picture in the lower part of fig. 13(b).) The effect of body angle of attack on the interference produced with the flaps is particularly evident in figure 16(c).[1] Thus for large deflections of the flaps, the agreement between the theoretical estimates and experiment is generally poor.

Lateral-directional characteristics.- The lateral- and directional-stability characteristics for the basic body with control set II undeflected (fig. 17) are very similar to the results for the body alone. Deflection of the side flaps appears to have little effect on the stability or on the linearity of the yawing- and rolling-moment coefficients for small angles of sideslip (fig. 17(b)).

As noted earlier, either an upper or a lower corner of the side controls of control set II could be deflected for roll control. Figure 19 illustrates how the controls could be used in combination to produce rolling moments with yawing moments nearly cancelled. Presented in this figure are the incremental aerodynamic characteristics obtained from the left flap deflected 90° and with its upper corner deflected 90° and from the right flap also deflected 90° with its lower corner deflected 90°. Adding the roll contributions of the two flaps results in a rolling-moment coefficient of 0.05 which is relatively insensitive to changes in angle of attack. The yawing moments of the two flaps tend to cancel and through the angle-of-attack range the resultant yawing moments are less than about 20 percent of the yawing moment produced by a single flap. The small pitching-moment contributions of the two flaps do not cancel; however, this moment could be eliminated by slightly lowering the side flaps to a position more in line with the assumed center of gravity.

[1]The curves in figure 16 are identified by their correspondence in length to the labeled scales at the top of the figure which show the angle of attack.

[redacted]

As shown in figure 20, the agreement between the experimental results and the theoretical estimates is good for small deflections of the side flaps to provide yaw and rolling moments. This is not the case for the larger flap deflections as illustrated at an angle of attack of 0° in figure 21. Included in this figure are results obtained in helium, which were used primarily to augment the air data at flap deflections of 45° and 60°. (A comparison between data obtained in air and helium is contained in the appendix.) Figure 21 indicates a large favorable interference effect which results in an increase in the effectiveness of the corners of the flaps to produce roll control. This interference effect is probably due in part to increased pressures produced by the main part of the flap acting on the deflected corners and in part to multiple compression through shock waves, as previously mentioned. The results of figure 21 also indicate that a 60° deflection of the flap for yaw results in the maximum rolling moments for all upper corner deflections of the flap except 0°.

If yawing of the body is acceptable, then the body rolling moment due to yaw (fig. 17(b)) could be used to supplement the rolling moment of a side flap with the lower corner deflected. If the technique of rolling the body to modulate the lift were used, a simplification of the control system could be made by the elimination of the pitch flaps.

Trim capability.- The pitch flaps of control set II were effective in changing the trim lift-drag ratios of the M-1 from +0.55 to -0.14 with a corresponding reduction in trim angle of attack from +13° to -24.5°. A summary of the trim capabilities of the pitch flaps determined both experimentally and theoretically is presented in figure 22. It is apparent from the experimental results that, if a fixed angle of attack is desired, the trim lift-drag ratios can be varied only a slight amount, generally about 0.1, through deflection of the pitch controls alone. The theoretical results show a somewhat larger possible variation, particularly at angles of attack near -10°. This and other distortions of the experimental curves of figure 22(a) relative to the curves from the theoretical estimates (fig. 22(b)) are due primarily to effects previously discussed.

Comparison of control sets.- Selected pitching-moment coefficients for control set II are repeated in figure 23 along with the results obtained for control set I. For pitch control, the flaps of control set I are used in pairs, and an estimate of the combined effectiveness has been obtained by multiplying the increment obtained for one flap by 2. Thus it is apparent, as also noted in references 6 and 10, that control set I is often more effective than control set II in providing trim in pitch. However, control set I has greater surface area so a comparison for equal flap areas might be more significant from a weight standpoint. Accordingly, the data for one flap of control set I have also been multiplied by 1-2/3 to give the equal area curves shown in figure 23. On this basis the controls on the upper surface are still more effective if located near the corner (i.e., control set I) rather than at the center (i.e., control set II). However, for the lower controls, the greater moment arm (primarily) of control set II results in the greater contribution to the pitching-moment coefficients.

Increments in rolling-moment coefficients for various flap deflections of control sets I and II are compared in figure 24 for one flap deflected in each case. The fairing of the upper curve in figure 24 is based on figure 21 which

[redacted]

includes helium data and data at other Mach numbers. These results indicate that control set II has a rolling-moment capability of more than double that for control set I.

Mach Number Effects

The variation of the longitudinal characteristics of the basic body with Mach number at 0° angle of attack is presented in figure 25 for a Mach number range from 0.7 to 21.5. The variation over the Mach number range of the present tests was slight, and in general the trends fit well with those for the other facilities included in figure 25. The Reynolds numbers for all the tests were generally about the same, as shown in figure 11. The effect of a variation in Mach number from 5 to 10 on the control characteristics was generally small, particularly for large control deflections as shown in figure 26. The aerodynamic characteristics at trimmed conditions for the basic body and for the basic body with the control sets undeflected are presented in figure 27 as a function of Mach number. The data from the present tests generally indicate little difference between the basic body and the body with flaps undeflected, although there are some differences in the angles of attack for trim. The static lateral-directional stability derivatives of the basic body and of the body with either control set undeflected were again similar, stable, and essentially constant in the hypersonic speed range (fig. 28). In general the results are comparable to those obtained in other facilities.

Unsteady Flow

A comparison of shadowgraph pictures, taken of a given flap configuration at a given tunnel condition but at different times, indicated a movement of the shock waves in the region of the flaps. Thus a series of shadowgraph pictures was taken at 0° angle of attack with control set II, in an attempt to obtain the extremes of this unsteady condition.

For the basic body, the body with upper flaps, or the body with the lower flap deflected 0° or 30°, no change in the shock-wave position was noted. Above 30°, the variation in shock-wave positions increased with flap deflection as shown by the superimposed pictures in figure 29. The disturbance in the shock waves does not appear to originate as a result of interference between the wind tunnel and the model because the double shock lines join and showed no disturbance as the tunnel boundary layer is approached. Generally the shock-wave motion was confined to the region immediately forward of the flap; but with the flap deflected 90°, the movement of the shock wave extended forward and nearer to the body as shown in figure 29(b). This fluctuation of the shock wave may be due to large pressure gradients with possible separated flow.

The shock-wave motion was possibly indicated in the force data, because the scatter in the pitching-moment data increased as the control deflection was increased. An example of this slight scatter in the pitching-moment coefficient is illustrated in figure 30 for a lower control deflected 60°. It should be noted that the scatter is reduced at large, negative angles of attack where the flap angle relative to the airstream is small; however, the scatter was generally small and rather inconclusive because it was within the maximum instrument errors. These results indicate that local unsteady-flow conditions occurred near the flaps, but it is not clear that the magnitude of the unsteady conditions is of any aerodynamic or structural concern.

Approximate Temperature Distributions

During the force tests, the model was coated with temperature-sensitive paint to provide a qualitative distribution of heating on the model. The results obtained were not intended to provide heat-transfer data, but rather to indicate approximately the distribution of heating or hot spots which could be correlated with the shadowgraph pictures.

The paints described in reference 13 had three or four color changes in the range from 150° F to 1500° F, and would respond with exposures of 30 seconds or less. A typical paint pattern obtained on the basic body is illustrated in figure 31. The paint used in this case had an original light green color which changed at temperatures up to 645° F as indicated in the figure. Observations and photographs taken in sequence showed that the lower surface of the model turned from a uniform blue (> 150° F) color to a uniform yellow (> 290° F) as the angle of attack was increased to 15°. The black color at the nose stagnation region is the metal showing through the eroded paint; the true paint color at the stagnation region was a brown (> 645° F). The diameter of this stagnation hot spot varied only slightly during the test run and amounted to only 4 percent of the reference base area after the test.

On the lower flaps the heating, as indicated by the paint, was roughly similar with either control set. A representative color pattern for large flap deflections is shown in figure 32 for a lower flap of control set I deflected 90°. For this case the flap was painted with a three-color yellow paint that turned gray at an uncalibrated temperature, orange (receding) at 790° F, and then gray (receding) at 1290° F. The response temperature of 1290° F was observed at small angles of attack as a faint gray line in the middle of the orange band across the flap. The position of the hot spot on the flap shown by the orange color in figure 32 varied only a little with angles of attack up to 15°. The location of the hot spot corresponded to the region where the body and flap shock waves coalesced (fig. 14(d)) and may be associated with the unsteady-flow effects previously discussed. The data indicated that the temperatures in the flap slot were lower than the flap or the local body temperatures. The hot spot on the body occurred at flap deflections of 60° or 90° and was greater in size for the larger angle and for the wider flaps of control set II.

CONCLUDING REMARKS

The following remarks are relative to wind-tunnel tests of the M-1 entry configuration at Mach numbers of 5.2, 7.4, and 10.4, at angles of attack from -30° to $+15^\circ$, and at Reynolds numbers of 400,000 to 1,200,000 based on the body length.

The basic body was self-trimming, was statically stable about all three axes, and had lateral- and directional-stability characteristics which were relatively insensitive to changes in angle of attack or Mach number. The effects of a change in body shape representative of that which might result from ablation during entry flight were found to be small.

Theoretical estimates, primarily based on impact theory, were satisfactory for an approximation of the experimental aerodynamic trends for the basic body without flaps or with small deflections of the flaps. With large deflections of the flaps the agreement between theory and experiment was often poor because large and varied effects of interference occurred between the body and flap flow fields.

With an aerodynamic control system consisting of single upper and lower flaps for pitch control, two side-mounted flaps for yaw control, and deflected corners on the yaw flaps for roll control, the configuration can be trimmed at lift-drag ratios from 0 to 0.5. The flaps on the lower surface of the model were generally more effective than those on the upper surface, and the roll control investigated was more effective than prior aerodynamic roll controls studied with the M-1 by a factor of about two. This control system also had little cross coupling.

The shadowgraphs indicated unsteady flow in the region where the body and flap shock waves coalesce. The motion of the shock waves was most apparent at large deflections of the flaps, and the degree of unsteadiness increased with flap deflection.

Qualitative tests utilizing heat-sensitive paint indicated localized hot spots on the flaps and on the body ahead of the flaps for deflections of the flaps equal to 60° or greater.

Ames Research Center
National Aeronautics and Space Administration
Moffett Field, Calif., Sept. 28, 1962

APPENDIX

A COMPARISON OF HELIUM AND AIR DATA

A comparison of the trends with Mach number between data obtained in helium and in air has already been made in the Mach number cross plots of figures 25 through 28. In these figures the data do not overlap, but for the test configuration the gas-dynamic characteristics do not vary significantly above a Mach number of 6 and their values seem to be as accurately defined in helium as in air.

Data representative of the results used to obtain the Mach number cross plots are presented in figures 33 and 34 for the basic body (side flaps at 0°) and for the lower pitch flap deflected 60°, respectively. The test conditions of Mach number (~10.5) and Reynolds number (~700,000) were essentially the same in the two test mediums so that a direct comparison of the results can be made. Figures 33 and 34 indicate that the trends in the aerodynamic characteristics with angle of attack for the M-1 with or without controls are well represented by the gas dynamic characteristics in helium.

There are absolute differences between the air and helium data, but these are generally not much greater than the differences (also shown in figs. 25 through 28) between results obtained in different facilities using air. The one exception is the large difference in the drag coefficients with the upper flap deflected 60°. The difference in this case may be due to separated flow which occurred on the upper surface of the model and to the differences in viscous effects in the two test mediums. The reasons for the small differences have not been analyzed; however, one theoretical possibility was considered, namely, that the maximum pressure coefficient is a function of the ratio of specific heats of the test medium. On this basis, modified impact theory would indicate that the data in helium at $\alpha = 0^{\circ}$ should be about 4 percent less than the data in air, not greater as the experimental results show.

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TABLE I.- BASIC BODY WITH SIDE CONTROLS AT 0° DEFLECTION, CONTROL SET II

(a) $M = 5.2$, $\alpha \approx -5^{\circ}$ to $+15^{\circ}$, $R = 800,000$

α, deg	C_L	C_D	L/D	C_m	C_{l_s}	C_{n_s}	C_Y	C_N	C_A	C_l	C_n
-5.03	0.302	0.5959	0.507	0.0108	-0.0001	-0.0013	-0.0004	0.2486	0.6201	-0.0002	-0.0013
-5.06	.302	.5966	.506	.0108	-.0001	-.0013	-.0009	.2479	.6209	-.0002	-.0013
-5.07	.301	.5953	.506	.0108	-.0001	-.0013	-.0007	.2476	.6196	-.0002	-.0013
-3.68	.321	.6194	.518	.0073	-.0001	-.0016	-.0003	.2803	.6388	-.0002	-.0016
-3.69	.320	.6189	.517	.0073	-.0001	-.0017	.0003	.2794	.6382	-.0002	-.0017
-3.69	.319	.6195	.516	.0074	-.0001	-.0016	-.0000	.2790	.6388	-.0002	-.0016
-2.23	.339	.6481	.523	.0034	-.0002	-.0019	-.0000	.3133	.6608	-.0003	-.0019
-2.23	.339	.6475	.524	.0034	-.0002	-.0019	-.0001	.3138	.6602	-.0003	-.0019
-2.23	.340	.6474	.524	.0034	-.0002	-.0018	-.0004	.3140	.6602	-.0003	-.0018
-1.28	.351	.6669	.527	.0005	-.0003	-.0020	-.0000	.3362	.6746	-.0003	-.0020
-1.28	.352	.6676	.527	.0006	-.0003	-.0020	.0001	.3365	.6753	-.0003	-.0020
-1.28	.351	.6665	.527	.0005	-.0002	-.0022	.0004	.3363	.6742	-.0003	-.0021
-.31	.363	.6877	.528	-.0024	-.0003	-.0023	.0003	.3594	.6896	-.0003	-.0023
-.31	.363	.6873	.528	-.0025	-.0003	-.0022	.0003	.3592	.6893	-.0003	-.0022
-.31	.363	.6864	.529	-.0026	-.0003	-.0023	.0005	.3591	.6884	-.0003	-.0023
.67	.374	.7083	.529	-.0055	-.0003	-.0024	.0006	.3828	.7039	-.0003	-.0024
.67	.374	.7086	.528	-.0054	-.0003	-.0023	.0007	.3827	.7042	-.0003	-.0024
.67	.374	.7068	.529	-.0056	-.0003	-.0024	.0007	.3821	.7024	-.0003	-.0024
1.70	.384	.7303	.526	-.0081	-.0004	-.0025	.0008	.4058	.7186	-.0003	-.0025
1.69	.385	.7314	.526	-.0079	-.0003	-.0026	.0011	.4060	.7197	-.0003	-.0026
1.69	.386	.7313	.527	-.0082	-.0003	-.0027	.0010	.4070	.7196	-.0003	-.0027
2.70	.393	.7517	.523	-.0101	-.0003	-.0027	.0014	.4279	.7323	-.0002	-.0028
2.69	.394	.7532	.523	-.0103	-.0004	-.0028	.0011	.4293	.7339	-.0003	-.0028
2.70	.395	.7537	.524	-.0104	-.0004	-.0027	.0012	.4298	.7343	-.0002	-.0028
3.70	.402	.7767	.518	-.0119	-.0004	-.0027	.0011	.4516	.7490	-.0003	-.0027
3.70	.401	.7728	.519	-.0120	-.0004	-.0027	.0011	.4502	.7452	-.0003	-.0028
3.70	.402	.7751	.519	-.0121	-.0004	-.0027	.0013	.4516	.7475	-.0002	-.0027
4.70	.408	.7961	.513	-.0133	-.0004	-.0027	.0013	.4723	.7600	-.0002	-.0028
4.69	.409	.7973	.513	-.0133	-.0005	-.0027	.0011	.4731	.7612	-.0003	-.0028
4.69	.409	.7974	.513	-.0132	-.0005	-.0027	.0010	.4727	.7612	-.0003	-.0027
5.69	.413	.8173	.506	-.0140	-.0005	-.0028	.0015	.4923	.7723	-.0002	-.0028
5.69	.413	.8175	.506	-.0139	-.0005	-.0028	.0014	.4923	.7725	-.0002	-.0028
5.69	.414	.8181	.506	-.0139	-.0005	-.0029	.0017	.4928	.7730	-.0002	-.0029
5.39	.411	.8123	.506	-.0136	-.0005	-.0028	.0012	.4855	.7701	-.0002	-.0028
4.91	.413	.8047	.514	-.0133	-.0004	-.0029	.0019	.4807	.7663	-.0002	-.0029
4.46	.408	.7903	.516	-.0134	-.0005	-.0027	.0006	.4683	.7562	-.0003	-.0027
8.19	.420	.8691	.484	-.0147	-.0006	-.0028	.0015	.5398	.8004	-.0002	-.0028
8.19	.420	.8686	.484	-.0147	-.0007	-.0028	.0014	.5399	.7999	-.0002	-.0028
8.19	.421	.8700	.484	-.0147	-.0006	-.0027	.0012	.5407	.8011	-.0003	-.0028
9.72	.421	.8982	.468	-.0151	-.0007	-.0028	.0013	.5662	.8144	-.0003	-.0028
9.72	.420	.8973	.468	-.0152	-.0008	-.0027	.0011	.5657	.8135	-.0003	-.0028
9.72	.421	.8979	.469	-.0153	-.0007	-.0027	.0012	.5666	.8139	-.0003	-.0027
10.74	.420	.9187	.457	-.0159	-.0008	-.0027	.0010	.5840	.8243	-.0003	-.0028
10.74	.420	.9170	.457	-.0158	-.0008	-.0027	.0011	.5831	.8228	-.0003	-.0028
10.74	.420	.9177	.457	-.0157	-.0008	-.0027	.0012	.5834	.8234	-.0003	-.0028
11.77	.418	.9360	.446	-.0164	-.0009	-.0025	.0008	.5997	.8311	-.0003	-.0026
11.77	.418	.9372	.446	-.0167	-.0008	-.0025	.0007	.6006	.8322	-.0003	-.0026
11.78	.418	.9364	.446	-.0164	-.0009	-.0025	.0008	.6000	.8314	-.0003	-.0026
12.79	.415	.9547	.435	-.0181	-.0009	-.0023	.0003	.6160	.8391	-.0004	-.0025
12.78	.415	.9552	.435	-.0182	-.0009	-.0024	.0007	.6162	.8396	-.0003	-.0025
12.79	.416	.9561	.435	-.0182	-.0009	-.0025	.0010	.6170	.8404	-.0003	-.0026
13.82	.414	.9786	.423	-.0205	-.0010	-.0027	.0009	.6353	.8515	-.0003	-.0028
13.82	.413	.9776	.423	-.0206	-.0010	-.0026	.0007	.6348	.8506	-.0004	-.0027
13.82	.414	.9773	.423	-.0207	-.0010	-.0026	.0007	.6351	.8502	-.0003	-.0027
14.85	.409	.9976	.410	-.0225	-.0010	-.0028	.0014	.6512	.8594	-.0003	-.0030
14.85	.409	.9971	.410	-.0224	-.0011	-.0029	.0017	.6510	.8590	-.0003	-.0031
14.85	.410	.9992	.410	-.0225	-.0011	-.0029	.0015	.6521	.8608	-.0003	-.0030
-.15	.371	.6973	.533	-.0034	-.0003	-.0022	.0001	.3696	.6983	-.0004	-.0022
-.17	.371	.6963	.533	-.0032	-.0003	-.0023	.0006	.3690	.6974	-.0003	-.0023
-.18	.371	.6970	.533	-.0033	-.0003	-.0022	.0003	.3692	.6982	-.0003	-.0022

[redacted]

TABLE I.- BASIC BODY WITH SIDE CONTROLS AT 0° DEFLECTION, CONTROL SET II - Continued

(b) $M = 5.2$, $\alpha \approx +5^\circ$ to -15°, $R = 800{,}000$

α, deg	C_L	C_D	L/D	C_m	C_{l_s}	C_{n_s}	C_Y	C_N	C_A	C_l	C_n
4.51	0.388	0.7881	0.492	-0.0052	-0.0000	-0.0045	0.0098	0.4487	0.7552	0.0003	-0.0045
4.55	.389	.7892	.493	-.0053	-.0001	-.0044	.0092	.4500	.7559	.0003	-.0044
4.58	.388	.7891	.492	-.0053	-.0001	-.0045	.0093	.4500	.7556	.0003	-.0045
3.70	.384	.7726	.497	-.0033	.0000	-.0045	.0095	.4329	.7462	.0003	-.0045
3.64	.383	.7719	.497	-.0033	-.0000	-.0044	.0090	.4317	.7460	.0003	-.0044
3.60	.384	.7708	.498	-.0034	.0000	-.0044	.0095	.4312	.7452	.0003	-.0044
2.21	.373	.7427	.502	-.0018	.0001	-.0040	.0087	.4015	.7278	.0003	-.0040
2.16	.372	.7425	.501	-.0016	.0001	-.0038	.0082	.3999	.7279	.0002	-.0038
2.13	.373	.7413	.503	-.0020	.0001	-.0038	.0079	.3998	.7270	.0002	-.0038
1.23	.365	.7242	.505	-.0007	.0001	-.0036	.0079	.3809	.7162	.0002	-.0036
1.19	.364	.7228	.504	-.0001	.0002	-.0036	.0080	.3791	.7151	.0002	-.0036
1.16	.364	.7224	.504	-.0002	.0002	-.0036	.0079	.3784	.7148	.0002	-.0036
.28	.356	.7058	.504	.0014	.0002	-.0034	.0076	.3592	.7040	.0002	-.0034
.23	.356	.7047	.504	.0012	.0002	-.0034	.0074	.3584	.7032	.0002	-.0034
.20	.355	.7034	.504	.0014	.0002	-.0034	.0074	.3572	.7022	.0002	-.0034
-.73	.345	.6852	.504	.0032	.0002	-.0032	.0070	.3367	.6896	.0002	-.0032
-.77	.345	.6853	.504	.0036	.0003	-.0032	.0069	.3359	.6898	.0002	-.0032
-.80	.344	.6843	.503	.0037	.0002	-.0032	.0066	.3346	.6891	.0002	-.0032
-1.73	.333	.6654	.500	.0056	.0003	-.0031	.0065	.3128	.6752	.0002	-.0031
-1.78	.332	.6651	.500	.0059	.0003	-.0030	.0065	.3115	.6750	.0002	-.0030
-1.81	.332	.6646	.500	.0059	.0003	-.0030	.0065	.3112	.6747	.0002	-.0030
-2.75	.320	.6463	.496	.0080	.0003	-.0029	.0062	.2891	.6609	.0002	-.0029
-2.79	.321	.6465	.496	.0082	.0004	-.0028	.0059	.2889	.6613	.0002	-.0028
-2.82	.320	.6457	.496	.0082	.0004	-.0028	.0059	.2879	.6607	.0002	-.0028
-3.76	.307	.6275	.490	.0100	.0004	-.0027	.0055	.2654	.6463	.0002	-.0027
-3.80	.306	.6270	.489	.0104	.0004	-.0026	.0050	.2642	.6459	.0002	-.0026
-3.83	.306	.6273	.488	.0105	.0004	-.0026	.0051	.2637	.6463	.0002	-.0026
-4.77	.292	.6100	.479	.0123	.0004	-.0025	.0050	.2407	.6322	.0002	-.0026
-4.81	.291	.6084	.478	.0127	.0004	-.0025	.0048	.2389	.6307	.0002	-.0025
-4.84	.291	.6084	.479	.0125	.0004	-.0026	.0052	.2388	.6308	.0002	-.0026
-5.75	.277	.5929	.467	.0144	.0005	-.0025	.0049	.2159	.6176	.0002	-.0025
-5.79	.277	.5933	.466	.0144	.0005	-.0025	.0050	.2154	.6182	.0002	-.0025
-5.82	.276	.5926	.466	.0147	.0005	-.0025	.0052	.2145	.6175	.0002	-.0026
-6.75	.261	.5767	.452	.0165	.0005	-.0023	.0044	.1913	.6034	.0002	-.0024
-6.79	.260	.5758	.451	.0165	.0005	-.0024	.0045	.1899	.6025	.0002	-.0024
-6.82	.259	.5759	.450	.0167	.0005	-.0024	.0046	.1891	.6027	.0002	-.0025
-8.27	.235	.5540	.423	.0193	.0005	-.0021	.0036	.1525	.5820	.0002	-.0021
-8.31	.233	.5531	.421	.0197	.0005	-.0021	.0037	.1504	.5810	.0002	-.0022
-8.34	.233	.5533	.421	.0198	.0005	-.0022	.0039	.1501	.5812	.0002	-.0022
-9.81	.206	.5326	.386	.0224	.0005	-.0020	.0030	.1121	.5599	.0002	-.0020
-9.85	.204	.5319	.384	.0227	.0005	-.0019	.0032	.1105	.5591	.0002	-.0020
-9.87	.204	.5318	.384	.0226	.0005	-.0019	.0030	.1101	.5589	.0002	-.0020
-10.86	.186	.5190	.358	.0245	.0005	-.0019	.0027	.0849	.5448	.0002	-.0020
-10.89	.185	.5192	.356	.0246	.0006	-.0020	.0030	.0836	.5448	.0002	-.0021
-10.92	.184	.5190	.354	.0250	.0006	-.0020	.0030	.0820	.5444	.0002	-.0021
-11.89	.167	.5086	.329	.0264	.0006	-.0019	.0027	.0588	.5321	.0001	-.0020
-11.93	.165	.5075	.325	.0268	.0006	-.0019	.0026	.0565	.5306	.0002	-.0020
-11.95	.165	.5077	.325	.0267	.0005	-.0018	.0023	.0565	.5309	.0001	-.0019
-12.91	.146	.4987	.293	.0289	.0005	-.0016	.0017	.0309	.5188	.0001	-.0017
-12.95	.145	.4981	.292	.0289	.0005	-.0017	.0017	.0301	.5180	.0001	-.0017
-12.97	.144	.4979	.289	.0292	.0006	-.0017	.0020	.0285	.5175	.0002	-.0018
-13.94	.126	.4896	.258	.0309	.0005	-.0015	.0014	.0045	.5055	.0001	-.0016
-13.97	.126	.4908	.256	.0313	.0005	-.0015	.0014	.0036	.5067	.0001	-.0016
-14.00	.125	.4899	.255	.0313	.0005	-.0015	.0014	.0027	.5056	.0001	-.0016
-14.48	.116	.4867	.238	.0320	.0005	-.0014	.0012	-.0093	.5002	.0001	-.0015
-14.50	.115	.4864	.237	.0322	.0005	-.0014	.0009	-.0105	.4997	.0001	-.0015
-14.52	.115	.4869	.236	.0326	.0005	-.0014	.0008	-.0109	.5001	.0001	-.0014
-.32	.352	.6986	.504	.0034	.0002	-.0029	.0060	.3480	.7006	.0002	-.0029
-.28	.352	.7003	.503	.0037	.0002	-.0029	.0059	.3487	.7020	.0002	-.0029
-.25	.352	.7003	.502	.0032	.0002	-.0030	.0061	.3488	.7019	.0002	-.0030

[redacted]

TABLE I.- BASIC BODY WITH SIDE CONTROLS AT 0° DEFLECTION, CONTROL SET II - Continued

(c) $M = 5.2$, $\alpha \approx -10^{\circ}$ to -30°, $R = 800{,}000$

α, deg	C_L	C_D	L/D	C_m	C_{l_s}	C_{n_s}	C_Y	C_N	C_A	C_l	C_n
-12.76	0.149	0.5052	0.296	0.0264	0.0002	-0.0023	0.0047	0.0341	0.5257	-0.0003	-0.0022
-12.80	.148	.5047	.293	.0262	.0001	-.0022	.0047	.0323	.5249	-.0004	-.0022
-12.84	.148	.5047	.294	.0263	.0001	-.0023	.0047	.0324	.5250	-.0004	-.0022
-13.74	.132	.4985	.266	.0278	.0001	-.0020	.0042	.0102	.5156	-.0004	-.0020
-13.78	.131	.4981	.263	.0280	.0001	-.0020	.0041	.0084	.5149	-.0003	-.0019
-13.81	.131	.4976	.263	.0277	.0001	-.0019	.0038	.0082	.5144	-.0004	-.0019
-14.69	.115	.4925	.234	.0293	.0001	-.0018	.0038	-.0135	.5056	-.0003	-.0017
-14.74	.114	.4922	.231	.0294	.0001	-.0018	.0038	-.0152	.5049	-.0003	-.0017
-14.78	.112	.4916	.229	.0296	.0001	-.0017	.0038	-.0167	.5040	-.0003	-.0017
-15.71	.095	.4865	.196	.0312	.0001	-.0015	.0032	-.0400	.4942	-.0003	-.0015
-15.75	.094	.4866	.194	.0314	.0001	-.0015	.0029	-.0412	.4940	-.0003	-.0014
-15.78	.094	.4869	.193	.0316	.0001	-.0015	.0030	-.0420	.4941	-.0003	-.0014
-16.72	.076	.4819	.157	.0336	.0001	-.0014	.0026	-.0661	.4833	-.0003	-.0014
-16.76	.074	.4825	.154	.0340	.0001	-.0013	.0023	-.0680	.4834	-.0003	-.0012
-16.80	.074	.4814	.154	.0338	.0001	-.0013	.0024	-.0681	.4823	-.0003	-.0013
-17.73	.056	.4798	.117	.0356	.0001	-.0011	.0015	-.0927	.4741	-.0003	-.0011
-17.78	.054	.4799	.114	.0358	.0001	-.0013	.0023	-.0946	.4736	-.0003	-.0012
-17.81	.055	.4801	.115	.0355	.0001	-.0012	.0019	-.0942	.4740	-.0003	-.0011
-18.74	.036	.4773	.076	.0373	.0001	-.0012	.0019	-.1188	.4637	-.0002	-.0012
-18.77	.036	.4781	.076	.0374	.0002	-.0012	.0020	-.1196	.4643	-.0002	-.0012
-18.80	.035	.4774	.073	.0374	.0001	-.0012	.0018	-.1207	.4632	-.0002	-.0012
-19.76	.014	.4771	.030	.0390	.0001	-.0010	.0013	-.1479	.4539	-.0002	-.0010
-19.80	.014	.4767	.030	.0391	.0002	-.0011	.0015	-.1481	.4533	-.0002	-.0011
-19.82	.013	.4770	.028	.0394	.0002	-.0011	.0014	-.1493	.4533	-.0002	-.0011
-20.75	-.007	.4782	-.014	.0409	.0001	-.0010	.0010	-.1758	.4448	-.0002	-.0010
-20.79	-.007	.4786	-.015	.0409	.0001	-.0011	.0012	-.1766	.4449	-.0002	-.0011
-20.82	-.007	.4787	-.015	.0407	.0002	-.0011	.0013	-.1769	.4449	-.0002	-.0011
-21.75	-.028	.4818	-.058	.0422	.0002	-.0011	.0011	-.2046	.4371	-.0003	-.0011
-21.79	-.029	.4816	-.060	.0424	.0002	-.0011	.0010	-.2055	.4365	-.0003	-.0011
-21.81	-.029	.4812	-.061	.0422	.0002	-.0011	.0009	-.2059	.4359	-.0002	-.0011
-23.28	-.061	.4874	-.124	.0436	.0003	-.0014	.0014	-.2482	.4238	-.0003	-.0014
-23.31	-.061	.4882	-.124	.0433	.0003	-.0015	.0016	-.2489	.4243	-.0003	-.0015
-23.34	-.062	.4883	-.126	.0435	.0004	-.0014	.0016	-.2500	.4240	-.0002	-.0015
-24.82	-.094	.4965	-.188	.0445	.0004	-.0014	.0016	-.2933	.4114	-.0002	-.0015
-24.86	-.094	.4965	-.188	.0443	.0004	-.0015	.0017	-.2936	.4112	-.0003	-.0015
-24.88	-.094	.4973	-.189	.0443	.0004	-.0015	.0017	-.2946	.4115	-.0002	-.0015
-25.87	-.113	.5042	-.225	.0443	.0005	-.0015	.0016	-.3218	.4043	-.0002	-.0016
-25.90	-.115	.5047	-.228	.0446	.0005	-.0015	.0016	-.3239	.4038	-.0002	-.0015
-25.92	-.115	.5045	-.228	.0446	.0005	-.0014	.0012	-.3240	.4035	-.0002	-.0015
-26.90	-.134	.5128	-.261	.0448	.0005	-.0016	.0017	-.3515	.3966	-.0003	-.0017
-26.94	-.135	.5120	-.263	.0448	.0006	-.0017	.0017	-.3521	.3954	-.0002	-.0017
-26.96	-.135	.5122	-.263	.0446	.0005	-.0017	.0016	-.3524	.3954	-.0003	-.0017
-27.93	-.154	.5238	-.294	.0447	.0006	-.0018	.0017	-.3813	.3907	-.0003	-.0018
-27.96	-.154	.5238	-.294	.0447	.0006	-.0018	.0019	-.3818	.3903	-.0003	-.0019
-27.99	-.156	.5241	-.297	.0447	.0006	-.0018	.0017	-.3833	.3898	-.0003	-.0019
-28.96	-.172	.5343	-.323	.0451	.0007	-.0019	.0017	-.4096	.3839	-.0003	-.0020
-29.00	-.173	.5342	-.323	.0447	.0006	-.0019	.0018	-.4100	.3836	-.0004	-.0020
-29.02	-.173	.5347	-.324	.0447	.0006	-.0019	.0018	-.4107	.3836	-.0004	-.0019
-29.51	-.182	.5401	-.337	.0447	.0006	-.0018	.0017	-.4245	.3803	-.0003	-.0019
-29.54	-.182	.5396	-.337	.0446	.0006	-.0018	.0015	-.4243	.3798	-.0003	-.0018
-29.55	-.182	.5398	-.337	.0446	.0006	-.0018	.0015	-.4246	.3798	-.0003	-.0019
-15.28	.101	.4888	.206	.0311	.0000	-.0010	.0017	-.0319	.4980	-.0003	-.0009
-15.26	.101	.4888	.206	.0309	.0000	-.0010	.0019	-.0314	.4981	-.0002	-.0010
-15.23	.102	.4892	.208	.0310	.0000	-.0010	.0017	-.0304	.4988	-.0002	-.0009

TABLE I.- BASIC BODY WITH SIDE CONTROLS AT 0° DEFLECTION, CONTROL SET II - Continued

(d) $M = 7.4$, $\alpha \approx -5^{\circ}$ to $+15^{\circ}$, $R = 800{,}000$

α, deg	C_L	C_D	L/D	C_m	C_{l_s}	C_{n_s}	C_Y	C_N	C_A	C_l	C_n
-5.42	0.264	0.5338	0.495	0.0112	0.0008	-0.0033	0.0084	0.2128	0.5564	0.0005	-0.0034
-5.43	.265	.5332	.497	.0111	.0008	-.0033	.0083	.2131	.5559	.0005	-.0033
-5.45	.264	.5339	.495	.0112	.0007	-.0032	.0079	.2125	.5566	.0004	-.0033
-3.89	.285	.5597	.510	.0092	.0008	-.0036	.0093	.2467	.5778	.0005	-.0036
-3.86	.286	.5602	.510	.0093	.0008	-.0035	.0092	.2475	.5782	.0005	-.0036
-3.84	.286	.5597	.511	.0090	.0008	-.0036	.0093	.2479	.5776	.0005	-.0036
-2.30	.306	.5864	.522	.0069	.0006	-.0035	.0085	.2824	.5982	.0004	-.0035
-2.25	.307	.5873	.523	.0069	.0006	-.0036	.0089	.2837	.5990	.0005	-.0036
-2.22	.307	.5879	.523	.0068	.0006	-.0035	.0088	.2842	.5994	.0005	-.0036
-1.23	.321	.6070	.529	.0053	.0005	-.0036	.0087	.3079	.6137	.0004	-.0036
-1.19	.320	.6074	.527	.0053	.0005	-.0036	.0090	.3076	.6140	.0005	-.0036
-1.17	.320	.6076	.527	.0053	.0005	-.0036	.0087	.3080	.6140	.0005	-.0036
-.29	.330	.6270	.527	.0043	.0005	-.0037	.0090	.3270	.6287	.0005	-.0037
-.19	.332	.6263	.530	.0038	.0005	-.0037	.0089	.3299	.6274	.0005	-.0037
-.14	.333	.6268	.531	.0037	.0005	-.0037	.0089	.3311	.6277	.0004	-.0037
.81	.344	.6470	.531	.0023	.0004	-.0038	.0094	.3528	.6421	.0005	-.0038
.84	.344	.6466	.531	.0021	.0004	-.0038	.0091	.3530	.6415	.0005	-.0038
.85	.344	.6471	.531	.0021	.0003	-.0037	.0087	.3535	.6420	.0004	-.0037
1.78	.353	.6653	.531	.0006	.0003	-.0039	.0090	.3738	.6540	.0004	-.0039
1.81	.353	.6663	.530	.0005	.0003	-.0039	.0091	.3742	.6547	.0004	-.0039
1.83	.353	.6663	.530	.0005	.0003	-.0039	.0089	.3742	.6547	.0004	-.0039
2.68	.360	.6856	.525	-.0007	.0002	-.0040	.0093	.3912	.6680	.0004	-.0040
2.75	.362	.6855	.528	-.0010	.0002	-.0040	.0092	.3941	.6674	.0004	-.0040
2.79	.362	.6865	.527	-.0011	.0002	-.0040	.0095	.3950	.6681	.0004	-.0040
3.72	.370	.7055	.524	-.0026	.0002	-.0040	.0094	.4148	.6800	.0004	-.0040
3.75	.369	.7058	.522	-.0024	.0001	-.0040	.0092	.4141	.6802	.0004	-.0040
3.76	.369	.7060	.523	-.0026	.0001	-.0040	.0090	.4146	.6803	.0004	-.0039
4.61	.373	.7250	.515	-.0036	.0000	-.0041	.0092	.4302	.6927	.0004	-.0041
4.69	.376	.7247	.519	-.0042	.0000	-.0041	.0093	.4340	.6916	.0004	-.0041
4.72	.377	.7257	.519	-.0042	.0000	-.0041	.0091	.4351	.6923	.0003	-.0041
5.66	.382	.7469	.512	-.0055	.0000	-.0042	.0095	.4541	.7056	.0004	-.0042
5.69	.381	.7469	.510	-.0053	.0000	-.0042	.0096	.4530	.7055	.0004	-.0042
5.69	.382	.7471	.511	-.0055	-.0001	-.0042	.0092	.4539	.7055	.0003	-.0041
6.61	.387	.7666	.505	-.0068	-.0002	-.0043	.0093	.4726	.7170	.0003	-.0043
6.64	.386	.7663	.503	-.0067	-.0002	-.0042	.0088	.4716	.7166	.0003	-.0042
6.65	.386	.7665	.504	-.0070	-.0002	-.0042	.0087	.4724	.7166	.0003	-.0042
8.07	.393	.7981	.492	-.0089	-.0003	-.0043	.0090	.5009	.7350	.0003	-.0044
8.10	.392	.7987	.491	-.0089	-.0003	-.0044	.0092	.5006	.7355	.0003	-.0044
8.11	.392	.7983	.491	-.0089	-.0003	-.0046	.0101	.5006	.7350	.0004	-.0046
9.55	.395	.8285	.476	-.0105	-.0005	-.0044	.0090	.5266	.7516	.0002	-.0045
9.58	.394	.8289	.476	-.0107	-.0004	-.0044	.0091	.5266	.7517	.0003	-.0044
9.59	.394	.8293	.476	-.0106	-.0005	-.0044	.0087	.5271	.7520	.0002	-.0044
10.45	.394	.8507	.464	-.0112	-.0005	-.0045	.0096	.5422	.7650	.0003	-.0046
10.52	.397	.8509	.466	-.0118	-.0005	-.0046	.0097	.5454	.7641	.0003	-.0046
10.55	.396	.8512	.465	-.0118	-.0006	-.0044	.0089	.5453	.7642	.0002	-.0045
11.50	.396	.8716	.455	-.0128	-.0006	-.0046	.0096	.5621	.7751	.0003	-.0046
11.55	.396	.8702	.455	-.0131	-.0007	-.0045	.0088	.5621	.7733	.0002	-.0046
11.56	.395	.8700	.454	-.0131	-.0007	-.0044	.0086	.5616	.7731	.0002	-.0045
12.53	.394	.8905	.442	-.0142	-.0008	-.0047	.0096	.5775	.7838	.0003	-.0047
12.55	.393	.8913	.441	-.0140	-.0008	-.0047	.0096	.5772	.7847	.0003	-.0047
12.55	.393	.8921	.441	-.0141	-.0008	-.0046	.0092	.5779	.7853	.0002	-.0047
13.45	.391	.9107	.429	-.0150	-.0009	-.0045	.0086	.5917	.7949	.0001	-.0046
13.51	.393	.9125	.431	-.0155	-.0009	-.0045	.0087	.5954	.7954	.0002	-.0046
13.53	.393	.9129	.430	-.0155	-.0009	-.0046	.0090	.5956	.7957	.0002	-.0046
14.52	.389	.9305	.418	-.0168	-.0010	-.0043	.0077	.6096	.8034	.0001	-.0044
14.53	.388	.9308	.416	-.0165	-.0010	-.0044	.0083	.6087	.8038	.0001	-.0045
14.53	.389	.9320	.417	-.0165	-.0010	-.0045	.0088	.6101	.8046	.0002	-.0046
-.06	.338	.6342	.533	.0035	.0006	-.0040	.0108	.3373	.6346	.0006	-.0040
-.21	.333	.6247	.533	.0034	.0006	-.0040	.0104	.3305	.6260	.0006	-.0040
-.31	.333	.6245	.533	.0037	.0006	-.0039	.0103	.3294	.6263	.0006	-.0039

TABLE I.- BASIC BODY WITH SIDE CONTROLS AT 0° DEFLECTION, CONTROL SET II - Continued

(e) $M = 7.4$, $\alpha \approx -15^\circ$ to $+5^\circ$, $R = 800,000$

α, deg	C_L	C_D	L/D	C_m	C_{l_s}	C_{n_s}	C_Y	C_N	C_A	C_l	C_n	C_{A_b}
-15.06	0.098	0.4345	0.225	0.0310	0.0008	-0.0020	0.0031	-0.0186	0.4450	0.0002	-0.0021	0.0222
-15.08	.098	.4343	.225	.0311	.0008	-.0021	.0033	-.0186	.4447	.0002	-.0022	.0225
-15.09	.098	.4334	.225	.0311	.0008	-.0021	.0033	-.0186	.4438	.0002	-.0022	.0225
-14.09	.113	.4370	.258	.0296	.0007	-.0021	.0033	.0030	.4513	.0002	-.0022	.0219
-14.09	.112	.4379	.256	.0298	.0008	-.0021	.0034	.0021	.4520	.0002	-.0022	.0218
-14.09	.112	.4379	.256	.0298	.0007	-.0021	.0030	.0020	.4520	.0002	-.0022	.0219
-13.10	.129	.4440	.290	.0284	.0006	-.0021	.0028	.0250	.4616	.0001	-.0021	.0214
-13.10	.128	.4443	.288	.0284	.0007	-.0021	.0028	.0238	.4617	.0002	-.0022	.0214
-13.10	.127	.4444	.287	.0285	.0007	-.0022	.0030	.0234	.4617	.0002	-.0023	.0214
-12.11	.145	.4522	.321	.0267	.0006	-.0021	.0025	.0469	.4726	.0001	-.0022	.0211
-12.10	.145	.4523	.321	.0266	.0006	-.0023	.0030	.0470	.4727	.0001	-.0024	.0212
-12.10	.144	.4524	.319	.0268	.0006	-.0023	.0029	.0462	.4725	.0001	-.0023	.0212
-11.12	.162	.4613	.351	.0250	.0006	-.0023	.0028	.0699	.4839	.0001	-.0023	.0212
-11.11	.161	.4605	.350	.0249	.0005	-.0023	.0025	.0694	.4829	.0001	-.0024	.0211
-11.11	.161	.4607	.350	.0250	.0005	-.0023	.0026	.0695	.4831	.0001	-.0023	.0212
-10.14	.179	.4711	.379	.0229	.0005	-.0023	.0028	.0930	.4952	.0001	-.0024	.0209
-10.13	.178	.4710	.377	.0231	.0005	-.0023	.0025	.0922	.4949	.0001	-.0023	.0212
-10.13	.178	.4709	.378	.0229	.0005	-.0022	.0026	.0924	.4948	.0001	-.0023	.0211
-8.66	.203	.4891	.414	.0203	.0004	-.0023	.0022	.1266	.5140	.0000	-.0024	.0213
-8.66	.203	.4882	.415	.0202	.0004	-.0024	.0026	.1269	.5132	.0001	-.0024	.0212
-8.66	.203	.4882	.416	.0200	.0004	-.0024	.0028	.1274	.5132	.0001	-.0025	.0212
-7.21	.228	.5078	.449	.0167	.0003	-.0025	.0023	.1625	.5324	.0000	-.0025	.0215
-7.20	.227	.5083	.446	.0169	.0003	-.0024	.0019	.1613	.5327	.0000	-.0024	.0217
-7.19	.227	.5084	.446	.0169	.0003	-.0026	.0024	.1614	.5328	.0000	-.0026	.0216
-6.25	.244	.5222	.467	.0146	.0002	-.0025	.0022	.1855	.5456	.0000	-.0025	.0217
-6.24	.243	.5229	.465	.0147	.0003	-.0026	.0025	.1849	.5462	.0000	-.0026	.0218
-6.23	.243	.5232	.465	.0148	.0002	-.0025	.0023	.1848	.5464	-.0001	-.0025	.0218
-5.28	.258	.5382	.479	.0130	.0002	-.0026	.0018	.2069	.5596	-.0001	-.0026	.0217
-5.28	.258	.5378	.480	.0129	.0001	-.0026	.0017	.2074	.5593	-.0001	-.0026	.0217
-5.28	.258	.5382	.480	.0129	.0001	-.0026	.0017	.2076	.5597	-.0001	-.0026	.0217
-4.32	.273	.5537	.492	.0110	.0001	-.0029	.0027	.2302	.5726	-.0001	-.0029	.0219
-4.30	.272	.5535	.492	.0107	.0001	-.0027	.0019	.2300	.5724	-.0001	-.0027	.0221
-4.30	.272	.5539	.492	.0109	.0001	-.0028	.0022	.2301	.5727	-.0001	-.0028	.0222
-3.36	.287	.5702	.503	.0091	.0001	-.0029	.0021	.2528	.5860	-.0001	-.0029	.0221
-3.35	.286	.5697	.502	.0092	.0000	-.0027	.0015	.2521	.5855	-.0002	-.0027	.0221
-3.34	.286	.5702	.502	.0091	-.0001	-.0027	.0011	.2524	.5859	-.0002	-.0027	.0222
-2.38	.299	.5865	.510	.0073	-.0001	-.0028	.0013	.2743	.5984	-.0002	-.0028	.0220
-2.38	.298	.5867	.509	.0072	-.0001	-.0027	.0009	.2738	.5985	-.0003	-.0027	.0221
-2.37	.299	.5859	.510	.0071	-.0001	-.0029	.0012	.2741	.5978	-.0002	-.0028	.0220
-1.42	.312	.6045	.516	.0055	-.0003	-.0028	.0006	.2968	.6121	-.0003	-.0028	.0220
-1.41	.312	.6047	.515	.0056	-.0002	-.0029	.0011	.2966	.6122	-.0003	-.0029	.0222
-1.40	.311	.6049	.515	.0056	-.0002	-.0030	.0015	.2963	.6123	-.0002	-.0030	.0222
-.47	.324	.6235	.520	.0040	-.0003	-.0030	.0009	.3191	.6261	-.0003	-.0030	.0220
-.45	.323	.6223	.519	.0038	-.0004	-.0028	.0000	.3181	.6249	-.0004	-.0028	.0220
-.45	.323	.6228	.519	.0040	-.0003	-.0029	.0006	.3182	.6253	-.0004	-.0029	.0220
.57	.335	.6411	.522	.0020	-.0005	-.0029	.0000	.3413	.6377	-.0004	-.0029	.0223
.59	.335	.6420	.522	.0020	-.0004	-.0030	.0005	.3417	.6386	-.0004	-.0030	.0219
.60	.336	.6433	.522	.0020	-.0005	-.0028	-.0006	.3422	.6398	-.0005	-.0028	.0220
1.61	.347	.6616	.524	.0002	-.0005	-.0030	.0002	.3650	.6517	-.0004	-.0030	.0222
1.63	.346	.6622	.522	.0003	-.0005	-.0030	.0002	.3643	.6521	-.0004	-.0030	.0221
1.64	.346	.6629	.522	.0001	-.0005	-.0030	.0000	.3649	.6527	-.0005	-.0030	.0221
3.24	.360	.6940	.519	-.0027	-.0007	-.0030	-.0003	.3991	.6726	-.0005	-.0030	.0222
3.26	.361	.6948	.520	-.0029	-.0006	-.0032	.0007	.4001	.6731	-.0004	-.0032	.0222
3.27	.361	.6952	.519	-.0028	-.0006	-.0030	.0000	.4001	.6734	-.0005	-.0030	.0219
4.86	.371	.7269	.511	-.0051	-.0008	-.0029	-.0008	.4318	.6928	-.0006	-.0030	.0223
4.89	.372	.7280	.511	-.0054	-.0008	-.0031	-.0003	.4323	.6937	-.0005	-.0031	.0221
4.90	.373	.7306	.511	-.0056	-.0008	-.0031	-.0002	.4340	.6961	-.0005	-.0032	.0220
-.07	.331	.6334	.522	.0032	-.0004	-.0028	.0000	.3299	.6338	-.0004	-.0028	.0221
-.30	.328	.6306	.520	.0039	-.0004	-.0029	.0000	.3244	.6323	-.0004	-.0029	.0220
-.43	.326	.6280	.519	.0040	-.0003	-.0030	.0009	.3212	.6305	-.0003	-.0030	.0220

[redacted]

TABLE I.- BASIC BODY WITH SIDE CONTROLS AT 0° DEFLECTION, CONTROL SET II - Continued

(f) $M = 7.4$, $\alpha \approx -10^{\circ}$ to -30°, $R = 800{,}000$

α, deg	C_L	C_D	L/D	C_m	C_{l_s}	C_{n_s}	C_Y	C_{A_b}
-9.89	0.195	0.4848	0.403	0.0215	-0.0008	-0.0021	-0.0017	0.0238
-9.87	.196	.4849	.404	.0214	-.0007	-.0022	-.0014	.0238
-9.86	.195	.4840	.404	.0214	-.0008	-.0022	-.0016	.0238
-11.42	.167	.4679	.357	.0248	-.0006	-.0022	-.0006	.0237
-11.45	.166	.4670	.355	.0250	-.0007	-.0021	-.0010	.0236
-11.47	.166	.4661	.356	.0248	-.0007	-.0021	-.0013	.0236
-13.01	.137	.4527	.302	.0276	-.0005	-.0019	-.0010	.0234
-13.06	.136	.4532	.301	.0277	-.0005	-.0020	-.0008	.0235
-13.09	.136	.4520	.301	.0276	-.0004	-.0021	.0000	.0236
-14.09	.116	.4448	.260	.0291	-.0004	-.0021	-.0002	.0235
-14.13	.115	.4445	.260	.0294	-.0004	-.0020	-.0004	.0236
-14.15	.115	.4447	.259	.0293	-.0005	-.0019	-.0012	.0235
-15.15	.095	.4389	.217	.0308	-.0004	-.0017	-.0010	.0238
-15.18	.095	.4386	.216	.0306	-.0004	-.0017	-.0012	.0238
-15.20	.095	.4382	.216	.0308	-.0004	-.0017	-.0010	.0238
-16.14	.077	.4351	.176	.0320	-.0003	-.0017	-.0012	-.0242
-16.16	.076	.4351	.175	.0322	-.0003	-.0018	-.0009	-.0242
-16.17	.076	.4347	.174	.0323	-.0003	-.0018	-.0012	-.0240
-17.13	.058	.4320	.134	.0333	-.0002	-.0016	-.0010	-.0246
-17.14	.058	.4313	.134	.0333	-.0002	-.0016	-.0013	-.0246
-17.15	.057	.4316	.133	.0335	-.0003	-.0015	-.0016	-.0246
-18.09	.040	.4298	.092	.0343	-.0002	-.0015	-.0013	-.0247
-18.12	.040	.4299	.092	.0343	-.0002	-.0016	-.0009	-.0249
-18.12	.040	.4306	.092	.0343	-.0002	-.0016	-.0008	-.0247
-19.00	.022	.4300	.052	.0353	-.0001	-.0016	-.0008	-.0252
-19.05	.021	.4292	.049	.0352	-.0001	-.0015	-.0008	-.0252
-19.07	.021	.4297	.049	.0354	-.0001	-.0015	-.0009	-.0249
-20.01	.003	.4306	.008	.0362	.0001	-.0016	.0002	-.0255
-20.04	.004	.4307	.008	.0364	.0000	-.0016	-.0001	-.0255
-20.05	.003	.4308	.008	.0364	-.0001	-.0014	-.0009	-.0256
-20.96	-.015	.4336	-.036	.0373	.0000	-.0015	-.0006	-.0261
-20.99	-.016	.4332	-.036	.0373	.0000	-.0015	-.0005	-.0261
-21.01	-.016	.4322	-.036	.0372	.0000	-.0015	-.0008	-.0259
-21.96	-.034	.4378	-.078	.0383	.0000	-.0014	-.0009	-.0264
-21.96	-.034	.4382	-.078	.0383	.0001	-.0015	-.0005	-.0264
-21.97	-.034	.4377	-.078	.0383	.0001	-.0015	-.0003	-.0265
-23.39	-.061	.4447	-.138	.0392	.0001	-.0015	-.0010	-.0269
-23.42	-.062	.4436	-.139	.0392	.0001	-.0015	-.0009	-.0267
-23.43	-.061	.4429	-.138	.0389	.0000	-.0014	-.0018	-.0267
-24.88	-.088	.4525	-.195	.0401	.0002	-.0017	-.0007	-.0268
-24.90	-.090	.4527	-.198	.0403	.0002	-.0016	-.0010	-.0268
-24.91	-.090	.4535	-.199	.0403	.0001	-.0015	-.0012	-.0268
-25.87	-.108	.4621	-.234	.0408	.0004	-.0016	.0003	-.0269
-25.89	-.107	.4602	-.234	.0406	.0003	-.0016	-.0002	-.0270
-25.90	-.109	.4607	-.236	.0408	.0002	-.0015	-.0007	-.0269
-26.87	-.126	.4714	-.267	.0410	.0003	-.0016	.0001	-.0271
-26.88	-.126	.4718	-.267	.0410	.0003	-.0014	-.0009	-.0272
-26.89	-.126	.4711	-.267	.0408	.0003	-.0015	-.0003	-.0272
-27.88	-.143	.4796	-.297	.0411	.0003	-.0013	-.0011	-.0274
-27.88	-.143	.4792	-.299	.0411	.0003	-.0012	-.0012	-.0274
-27.88	-.144	.4802	-.300	.0411	.0003	-.0013	-.0005	-.0274
-28.85	-.162	.4914	-.330	.0413	.0005	-.0014	-.0001	-.0277
-28.87	-.162	.4907	-.329	.0412	.0005	-.0014	-.0002	-.0278
-28.88	-.161	.4903	-.327	.0409	.0005	-.0014	-.0001	-.0277
-29.85	-.179	.5018	-.356	.0412	.0006	-.0013	-.0004	-.0282
-29.87	-.177	.5018	-.354	.0410	.0004	-.0013	-.0009	-.0282
-29.87	-.178	.5027	-.354	.0412	.0004	-.0013	-.0013	-.0280
-15.22	.091	.4358	.208	.0312	-.0005	-.0018	-.0017	.0240
-15.13	.092	.4350	.212	.0307	-.0004	-.0019	-.0011	.0238
-15.01	.096	.4345	.220	.0305	-.0005	-.0017	-.0021	.0238

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TABLE I.- BASIC BODY WITH SIDE CONTROLS AT 0° DEFLECTION, CONTROL SET II - Continued

(g) $M = 10.4$, $\alpha \approx -4^{\circ}$ to $+15^{\circ}$, $R = 600{,}000$

α, deg	C_L	C_D	L/D	C_m	C_{l_s}	C_{n_s}	C_Y	C_N	C_A	C_l	C_n
-3.55	0.277	0.5187	0.533	0.0052	-0.0004	-0.0027	0.0005	0.2439	0.5348	-0.0006	-0.0027
-3.52	.276	.5187	.532	.0051	-.0004	-.0028	.0009	.2437	.5347	-.0006	-.0028
-3.51	.276	.5194	.531	.0052	-.0003	-.0029	.0013	.2434	.5353	-.0005	-.0029
-1.95	.303	.5510	.550	.0009	-.0004	-.0031	.0022	.2841	.5610	-.0005	-.0031
-1.92	.302	.5515	.547	.0012	-.0003	-.0031	.0031	.2830	.5613	-.0004	-.0031
-1.91	.301	.5527	.544	.0019	-.0003	-.0034	.0035	.2824	.5624	-.0004	-.0034
-.91	.315	.5691	.554	-.0019	-.0007	-.0026	-.0003	.3061	.5740	-.0008	-.0026
-.88	.314	.5689	.552	-.0016	-.0007	-.0028	.0011	.3055	.5736	-.0007	-.0028
-.86	.311	.5680	.548	-.0002	-.0003	-.0034	.0045	.3028	.5726	-.0003	-.0034
.11	.338	.5987	.564	-.0039	-.0006	-.0029	.0014	.3391	.5981	-.0006	-.0029
.15	.331	.5951	.556	-.0036	-.0003	-.0037	.0054	.3327	.5942	-.0003	-.0037
.17	.324	.5877	.552	-.0032	-.0006	-.0031	.0025	.3260	.5867	-.0006	-.0031
1.11	.346	.6211	.557	-.0053	-.0008	-.0029	.0006	.3580	.6142	-.0008	-.0029
1.13	.345	.6181	.558	-.0060	-.0004	-.0037	.0048	.3570	.6111	-.0003	-.0038
1.14	.334	.6063	.551	-.0047	-.0003	-.0038	.0049	.3459	.5996	-.0003	-.0038
2.08	.347	.6345	.546	-.0062	-.0008	-.0029	.0014	.3694	.6215	-.0007	-.0030
2.10	.354	.6401	.553	-.0075	-.0007	-.0030	.0020	.3772	.6267	-.0006	-.0030
2.10	.346	.6305	.548	-.0067	-.0004	-.0033	.0042	.3687	.6173	-.0003	-.0033
3.04	.346	.6440	.537	-.0066	-.0009	-.0025	.0008	.3793	.6247	-.0008	-.0025
3.07	.355	.6484	.548	-.0088	-.0008	-.0028	.0020	.3893	.6285	-.0006	-.0029
3.07	.365	.6560	.556	-.0110	-.0006	-.0035	.0050	.3992	.6355	-.0004	-.0035
4.02	.368	.6788	.542	-.0113	-.0004	-.0042	.0067	.4145	.6514	-.0002	-.0042
4.03	.372	.6811	.546	-.0118	-.0008	-.0033	.0031	.4186	.6533	-.0006	-.0033
4.04	.371	.6796	.546	-.0113	-.0007	-.0033	.0035	.4181	.6518	-.0005	-.0034
4.97	.377	.7015	.538	-.0134	-.0009	-.0032	.0036	.4367	.6661	-.0007	-.0032
4.99	.378	.7013	.539	-.0134	-.0010	-.0026	.0014	.4374	.6658	-.0008	-.0027
4.99	.368	.6880	.535	-.0134	-.0008	-.0033	.0040	.4265	.6534	-.0006	-.0033
5.93	.372	.7113	.522	-.0121	-.0007	-.0040	.0072	.4430	.6691	-.0003	-.0040
5.95	.380	.7245	.524	-.0117	-.0009	-.0037	.0050	.4528	.6813	-.0005	-.0038
5.95	.388	.7310	.531	-.0136	-.0005	-.0037	.0077	.4616	.6868	-.0001	-.0037
6.89	.389	.7515	.518	-.0140	-.0006	-.0047	.0094	.4763	.6994	.0000	-.0048
6.91	.385	.7469	.516	-.0143	-.0008	-.0043	.0079	.4721	.6952	-.0003	-.0043
6.91	.384	.7458	.515	-.0135	-.0010	-.0036	.0048	.4708	.6942	-.0006	-.0037
8.36	.387	.7731	.501	-.0166	-.0007	-.0047	.0098	.4953	.7087	-.0000	-.0048
8.36	.390	.7777	.501	-.0168	-.0007	-.0044	.0098	.4989	.7127	-.0000	-.0044
8.37	.394	.7826	.504	-.0173	-.0011	-.0037	.0060	.5041	.7169	-.0005	-.0038
9.83	.401	.8200	.489	-.0207	-.0014	-.0033	.0039	.5351	.7396	-.0008	-.0035
9.84	.409	.8325	.491	-.0207	-.0012	-.0039	.0059	.5448	.7504	-.0005	-.0040
9.84	.403	.8236	.490	-.0209	-.0013	-.0037	.0049	.5382	.7425	-.0006	-.0038
10.81	.404	.8475	.477	-.0213	-.0015	-.0042	.0052	.5562	.7566	-.0007	-.0044
10.82	.406	.8509	.477	-.0222	-.0016	-.0037	.0037	.5586	.7595	-.0009	-.0039
10.82	.405	.8478	.478	-.0221	-.0017	-.0033	.0017	.5573	.7565	-.0011	-.0036
11.80	.405	.8701	.465	-.0243	-.0013	-.0051	.0102	.5741	.7690	-.0002	-.0053
11.81	.403	.8640	.466	-.0250	-.0015	-.0046	.0073	.5708	.7634	-.0005	-.0049
11.81	.404	.8678	.466	-.0240	-.0015	-.0041	.0055	.5731	.7667	-.0006	-.0043
12.78	.409	.9028	.453	-.0242	-.0018	-.0048	.0076	.5981	.7901	-.0007	-.0050
12.79	.406	.8949	.453	-.0242	-.0019	-.0040	.0037	.5936	.7829	-.0009	-.0044
12.79	.404	.8901	.453	-.0258	-.0016	-.0045	.0071	.5907	.7787	-.0006	-.0047
13.77	.404	.9206	.439	-.0261	-.0016	-.0055	.0101	.6118	.7979	-.0003	-.0057
13.78	.400	.9152	.437	-.0256	-.0017	-.0052	.0090	.6066	.7936	-.0005	-.0054
13.77	.400	.9126	.438	-.0261	-.0019	-.0047	.0066	.6058	.7911	-.0007	-.0050
14.76	.405	.9418	.430	-.0292	-.0018	-.0052	.0090	.6313	.8075	-.0004	-.0054
14.77	.398	.9337	.427	-.0278	-.0019	-.0046	.0074	.6232	.8013	-.0006	-.0049
14.77	.399	.9367	.426	-.0271	-.0017	-.0047	.0081	.6246	.8041	-.0004	-.0050
-.24	.372	.6176	.602	-.0037	-.0005	-.0032	.0027	.3692	.6192	-.0005	-.0032
-.19	.342	.6278	.544	-.0008	-.0003	-.0035	.0039	.3398	.6289	-.0004	-.0035
-.18	.341	.6225	.547	-.0015	-.0008	-.0027	-.0003	.3386	.6236	-.0008	-.0027

[redacted]

TABLE I.- BASIC BODY WITH SIDE CONTROLS AT 0° DEFLECTION, CONTROL SET II - Continued

(h) $M = 10.4$, $\alpha \approx -15^{\circ}$ to $+5^{\circ}$, $R = 600{,}000$

α, deg	C_L	C_D	L/D	C_m	C_{l_s}	C_{n_s}	C_Y	C_N	C_A	C_l	C_n
-15.12	0.089	0.3855	0.230	0.0260	0.0014	-0.0031	0.0085	-0.0149	0.3953	0.0006	-0.0034
-15.12	.092	.3893	.237	.0261	.0016	-.0035	.0095	-.0124	.3999	.0006	-.0038
-15.12	.096	.3903	.246	.0255	.0017	-.0036	.0104	-.0092	.4018	.0007	-.0039
-14.12	.104	.3936	.265	.0246	.0014	-.0034	.0089	.0051	.4072	.0006	-.0036
-14.11	.106	.3953	.269	.0250	.0016	-.0036	.0103	.0067	.4093	.0006	-.0039
-14.11	.105	.3943	.265	.0250	.0016	-.0034	.0095	.0053	.4079	.0007	-.0037
-13.13	.121	.4007	.301	.0234	.0012	-.0034	.0090	.0265	.4176	.0004	-.0035
-13.13	.124	.4014	.309	.0228	.0012	-.0033	.0088	.0297	.4191	.0005	-.0035
-13.12	.123	.4005	.307	.0228	.0014	-.0034	.0094	.0287	.4179	.0006	-.0036
-12.14	.137	.4073	.335	.0213	.0011	-.0033	.0088	.0479	.4269	.0004	-.0034
-12.14	.139	.4078	.341	.0214	.0011	-.0031	.0075	.0501	.4279	.0004	-.0033
-12.14	.139	.4083	.340	.0213	.0012	-.0033	.0082	.0497	.4283	.0005	-.0035
-11.16	.156	.4181	.373	.0198	.0010	-.0033	.0070	.0722	.4404	.0003	-.0034
-11.15	.156	.4156	.374	.0191	.0010	-.0032	.0078	.0723	.4379	.0004	-.0033
-11.15	.155	.4184	.371	.0198	.0010	-.0033	.0070	.0713	.4405	.0003	-.0034
-10.16	.171	.4276	.399	.0176	.0010	-.0034	.0087	.0924	.4510	.0003	-.0036
-10.16	.170	.4276	.397	.0176	.0009	-.0033	.0083	.0917	.4508	.0003	-.0034
-10.16	.171	.4262	.400	.0174	.0011	-.0038	.0094	.0926	.4496	.0004	-.0040
-8.70	.195	.4454	.438	.0149	.0011	-.0039	.0102	.1254	.4698	.0005	-.0040
-8.70	.199	.4464	.445	.0141	.0011	-.0038	.0098	.1290	.4713	.0005	-.0040
-8.70	.195	.4445	.439	.0150	.0011	-.0037	.0086	.1257	.4689	.0005	-.0038
-7.24	.218	.4627	.471	.0117	.0008	-.0036	.0080	.1577	.4865	.0003	-.0037
-7.23	.219	.4659	.470	.0123	.0010	-.0040	.0097	.1585	.4897	.0004	-.0041
-7.23	.220	.4655	.472	.0116	.0008	-.0037	.0088	.1594	.4895	.0003	-.0038
-6.28	.231	.4764	.484	.0102	.0008	-.0040	.0088	.1771	.4988	.0003	-.0041
-6.28	.231	.4776	.484	.0107	.0008	-.0039	.0095	.1774	.5000	.0003	-.0039
-6.28	.232	.4806	.484	.0101	.0008	-.0039	.0089	.1785	.5032	.0003	-.0040
-5.32	.248	.4931	.502	.0082	.0006	-.0040	.0087	.2008	.5139	.0003	-.0040
-5.32	.247	.4937	.500	.0089	.0008	-.0040	.0098	.2000	.5145	.0004	-.0041
-5.32	.246	.4950	.497	.0088	.0010	-.0044	.0121	.1991	.5157	.0006	-.0045
-4.36	.260	.5076	.512	.0064	.0004	-.0038	.0068	.2203	.5259	.0001	-.0038
-4.36	.257	.5062	.507	.0066	.0007	-.0041	.0090	.2176	.5242	.0003	-.0042
-4.36	.260	.5080	.513	.0064	.0007	-.0045	.0101	.2211	.5263	.0004	-.0045
-3.40	.271	.5225	.519	.0052	.0006	-.0044	.0094	.2396	.5376	.0003	-.0044
-3.40	.271	.5237	.518	.0053	.0008	-.0047	.0116	.2395	.5388	.0005	-.0048
-3.40	.270	.5229	.517	.0053	.0008	-.0047	.0113	.2388	.5380	.0005	-.0048
-2.43	.286	.5438	.526	.0037	.0002	-.0037	.0069	.2626	.5554	.0001	-.0037
-2.42	.287	.5444	.527	.0037	.0005	-.0041	.0086	.2635	.5560	.0003	-.0041
-2.42	.284	.5440	.523	.0043	.0001	-.0039	.0062	.2612	.5556	-.0001	-.0039
-1.48	.292	.5575	.524	.0032	.0000	-.0035	.0052	.2777	.5649	-.0001	-.0035
-1.47	.294	.5591	.525	.0029	.0000	-.0037	.0054	.2794	.5665	-.0001	-.0037
-1.47	.294	.5617	.524	.0029	.0001	-.0041	.0058	.2798	.5691	.0000	-.0041
-.51	.308	.5818	.529	.0020	-.0003	-.0036	.0025	.3024	.5845	-.0004	-.0036
-.50	.310	.5827	.532	.0008	.0001	-.0042	.0070	.3050	.5854	.0001	-.0042
-.50	.306	.5787	.528	.0016	.0003	-.0044	.0083	.3008	.5814	.0003	-.0044
.53	.314	.6002	.524	.0009	.0003	-.0048	.0097	.3199	.5972	.0004	-.0048
.53	.313	.5975	.524	.0006	.0003	-.0045	.0093	.3183	.5945	.0003	-.0045
.53	.317	.5968	.531	-.0007	-.0002	-.0040	.0058	.3224	.5938	-.0001	-.0040
1.56	.325	.6172	.527	-.0011	-.0003	-.0040	.0049	.3421	.6081	-.0002	-.0040
1.57	.323	.6186	.523	.0000	-.0006	-.0039	.0031	.3401	.6096	-.0005	-.0039
1.57	.322	.6148	.524	-.0005	-.0004	-.0039	.0041	.3386	.6057	-.0002	-.0040
3.17	.338	.6501	.520	-.0025	.0003	-.0052	.0125	.3738	.6303	.0006	-.0052
3.18	.338	.6529	.518	-.0022	-.0002	-.0044	.0067	.3740	.6331	.0000	-.0044
3.19	.337	.6493	.519	-.0023	-.0005	-.0042	.0045	.3728	.6296	-.0003	-.0043
4.79	.353	.6862	.514	-.0046	-.0004	-.0047	.0075	.4088	.6543	-.0000	-.0047
4.80	.351	.6908	.508	-.0022	-.0009	-.0038	.0016	.4073	.6591	-.0005	-.0038
4.80	.350	.6856	.511	-.0037	-.0010	-.0040	.0016	.4065	.6539	-.0006	-.0040
-.44	.307	.5876	.523	.0013	-.0003	-.0033	.0017	.3029	.5900	-.0003	-.0033
-.37	.311	.5864	.530	.0012	-.0002	-.0033	.0030	.3068	.5885	-.0003	-.0033
-.34	.311	.5903	.527	.0020	-.0003	-.0031	.0019	.3076	.5921	-.0003	-.0031

TABLE I.- BASIC BODY WITH SIDE CONTROLS AT 0° DEFLECTION, CONTROL SET II - Concluded

(i) $M = 10.4$, $\alpha \approx -30^{\circ}$ to -10°, $R = 600,000$

α, deg	C_L	C_D	L/D	C_m	C_{l_s}	C_{n_s}	C_Y	C_N	C_A	C_l	C_n
-29.96	-0.175	0.4381	-0.399	0.0412	-0.0001	-0.0003	0.0011	-0.3702	0.2923	-0.0002	-0.0002
-29.96	-.173	.4398	-.393	.0409	.0004	.0000	.0003	-.3695	.2947	.0003	-.0002
-29.96	-.169	.4397	-.384	.0408	.0002	.0003	-.0011	-.3658	.2966	.0003	.0002
-28.93	-.157	.4288	-.367	.0412	.0001	-.0001	.0006	-.3453	.2991	.0000	-.0001
-28.93	-.156	.4270	-.365	.0409	.0004	-.0002	.0011	-.3428	.2984	.0003	-.0004
-28.93	-.159	.4297	-.370	.0420	.0002	.0001	-.0002	-.3472	.2991	.0002	.0000
-27.96	-.138	.4177	-.330	.0399	.0002	.0001	.0000	-.3177	.3042	.0002	.0000
-27.95	-.139	.4183	-.332	.0410	.0003	.0002	.0000	-.3188	.3044	.0003	.0001
-27.95	-.141	.4211	-.335	.0409	.0002	-.0003	.0014	-.3219	.3060	.0000	-.0004
-26.96	-.124	.4108	-.302	.0402	.0003	-.0003	.0004	-.2969	.3098	.0001	-.0004
-26.96	-.124	.4106	-.302	.0409	.0005	-.0009	.0033	-.2966	.3098	.0000	-.0010
-26.96	-.123	.4102	-.300	.0405	.0003	-.0003	.0005	-.2958	.3097	.0002	-.0004
-25.99	-.105	.4007	-.261	.0398	.0003	-.0009	.0030	-.2696	.3144	-.0002	-.0009
-25.98	-.110	.4046	-.271	.0414	.0002	-.0008	.0031	-.2758	.3157	-.0001	-.0008
-25.98	-.107	.4034	-.266	.0412	-.0001	.0000	-.0011	-.2733	.3156	-.0001	.0000
-24.99	-.094	.3996	-.236	.0400	.0002	-.0005	.0016	-.2544	.3223	.0000	-.0006
-24.99	-.087	.3975	-.219	.0394	.0001	.0002	-.0018	-.2468	.3235	.0002	.0001
-24.99	-.088	.3976	-.221	.0398	.0002	-.0002	.0010	-.2475	.3233	.0001	-.0003
-23.54	-.063	.3850	-.165	.0383	-.0001	-.0003	.0004	-.2119	.3276	-.0002	-.0002
-23.53	-.063	.3866	-.162	.0389	.0003	-.0012	.0041	-.2119	.3294	-.0002	-.0012
-23.53	-.063	.3863	-.163	.0391	.0001	-.0006	.0010	-.2118	.3291	-.0001	-.0006
-22.08	-.035	.3808	-.093	.0365	.0000	-.0007	.0005	-.1759	.3395	-.0003	-.0007
-22.07	-.040	.3827	-.105	.0373	-.0001	-.0001	-.0022	-.1809	.3396	-.0001	-.0001
-22.07	-.038	.3796	-.100	.0370	.0000	-.0006	.0017	-.1778	.3375	-.0002	-.0005
-21.12	-.023	.3713	-.061	.0368	.0001	-.0009	.0012	-.1550	.3382	-.0002	-.0008
-21.12	-.020	.3729	-.054	.0361	.0002	-.0009	.0026	-.1531	.3406	-.0002	-.0009
-21.12	-.020	.3733	-.055	.0359	.0000	-.0011	.0028	-.1536	.3409	-.0004	-.0010
-20.16	-.004	.3747	-.011	.0348	.0000	-.0007	.0015	-.1329	.3503	-.0002	-.0007
-20.16	-.008	.3742	-.021	.0351	.0001	-.0017	.0057	-.1363	.3485	-.0005	-.0016
-20.16	-.004	.3762	-.011	.0347	-.0001	-.0013	.0034	-.1334	.3517	-.0006	-.0012
-19.21	.015	.3710	.041	.0346	.0004	-.0017	.0062	-.1076	.3553	-.0002	-.0017
-19.20	.013	.3779	.035	.0352	-.0001	-.0011	.0019	-.1118	.3612	-.0004	-.0010
-19.20	.011	.3753	.028	.0349	-.0003	-.0007	-.0015	-.1133	.3579	-.0005	-.0005
-18.24	.024	.3741	.063	.0335	-.0001	-.0014	.0017	-.0947	.3627	-.0005	-.0013
-18.24	.026	.3730	.071	.0328	.0003	-.0016	.0044	-.0917	.3625	-.0002	-.0016
-18.24	.029	.3755	.078	.0331	.0003	-.0019	.0049	-.0896	.3659	-.0003	-.0019
-17.28	.044	.3726	.117	.0314	.0000	-.0018	.0035	-.0689	.3687	-.0006	-.0017
-17.27	.041	.3749	.110	.0322	.0000	-.0015	.0032	-.0719	.3702	-.0004	-.0015
-17.27	.043	.3707	.116	.0318	-.0003	-.0014	.0016	-.0689	.3668	-.0007	-.0013
-16.32	.061	.3717	.164	.0293	.0001	-.0015	.0033	-.0458	.3739	-.0003	-.0015
-16.32	.058	.3741	.155	.0296	-.0002	-.0013	.0027	-.0495	.3753	-.0006	-.0012
-16.32	.062	.3785	.163	.0297	-.0004	-.0012	.0023	-.0470	.3806	-.0008	-.0010
-15.35	.078	.3785	.207	.0286	-.0002	-.0018	.0044	-.0248	.3857	-.0006	-.0017
-15.35	.078	.3798	.205	.0285	-.0003	-.0016	.0017	-.0255	.3868	-.0007	-.0014
-15.35	.077	.3804	.202	.0282	.0001	-.0023	.0049	-.0267	.3871	-.0005	-.0022
-14.33	.092	.3867	.237	.0277	-.0003	-.0017	.0026	-.0070	.3974	-.0007	-.0015
-14.33	.096	.3934	.243	.0275	.0003	-.0028	.0083	-.0046	.4048	-.0003	-.0028
-14.33	.096	.3900	.245	.0275	.0009	-.0035	.0134	-.0040	.4015	.0000	-.0036
-13.30	.111	.3936	.283	.0258	.0001	-.0025	.0065	.0180	.4087	-.0005	-.0025
-13.30	.111	.3935	.282	.0260	-.0002	-.0022	.0044	.0176	.4085	-.0007	-.0021
-13.29	.111	.3921	.284	.0254	-.0001	-.0025	.0070	.0182	.4072	-.0007	-.0024
-11.68	.144	.4087	.353	.0225	-.0008	-.0016	-.0002	.0586	.4295	-.0011	-.0014
-11.68	.140	.4096	.343	.0229	-.0007	-.0017	.0020	.0545	.4295	-.0010	-.0016
-11.68	.142	.4077	.348	.0226	-.0004	-.0022	.0045	.0563	.4280	-.0009	-.0020
-10.07	.173	.4337	.398	.0207	-.0009	-.0023	.0013	.0941	.4572	-.0013	-.0021
-10.07	.175	.4254	.412	.0186	.0000	-.0038	.0097	.0980	.4495	-.0006	-.0037
-10.07	.174	.4310	.403	.0199	.0001	-.0034	.0090	.0955	.4547	-.0004	-.0033
-15.14	.081	.3906	.207	.0292	.0004	-.0026	.0091	-.0239	.3982	-.0003	-.0026
-15.20	.079	.3921	.201	.0294	-.0002	-.0019	.0042	-.0268	.3990	-.0007	-.0018
-15.17	.080	.3882	.205	.0290	-.0004	-.0015	.0024	-.0247	.3955	-.0008	-.0013

[redacted]

[redacted]

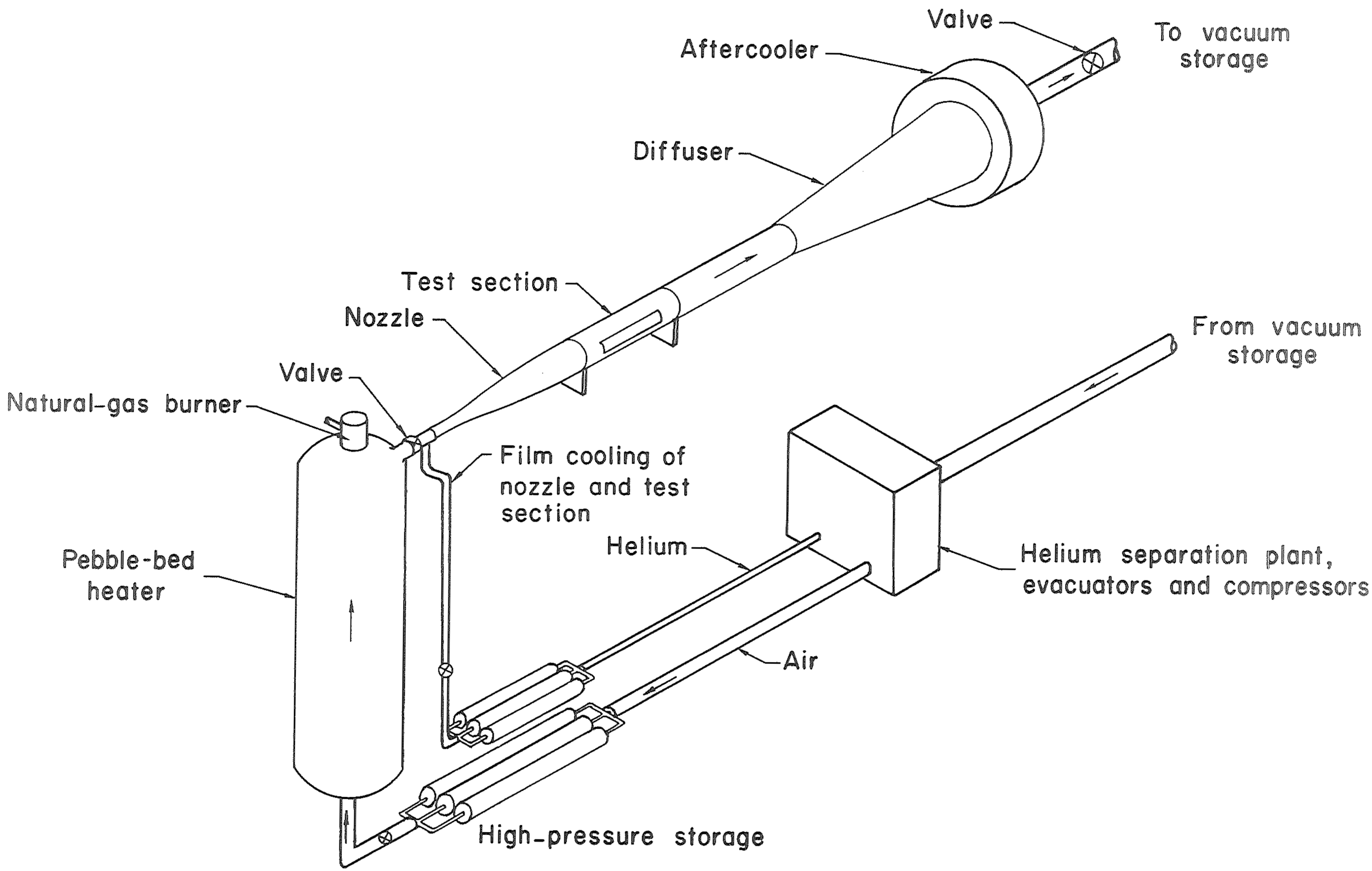
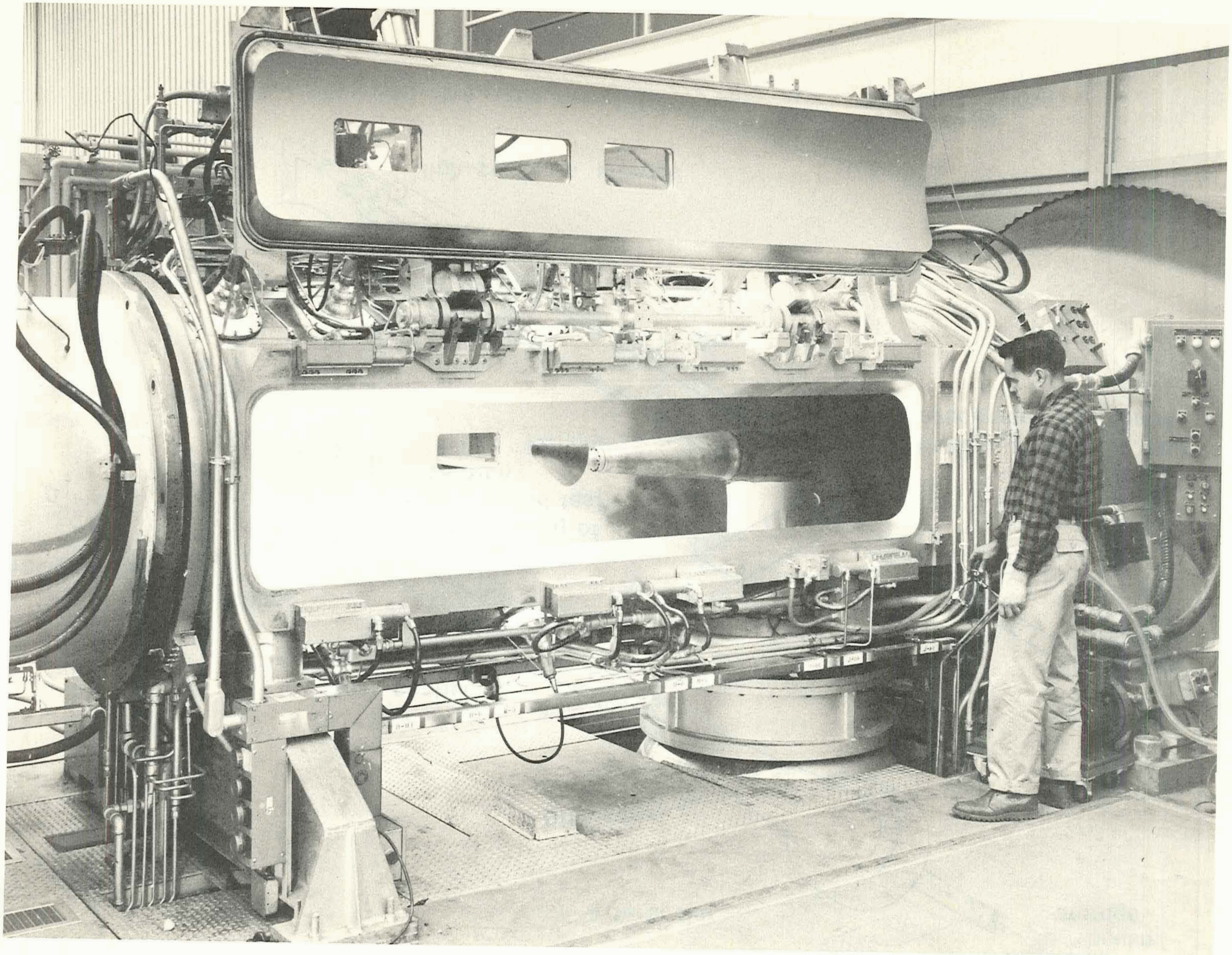


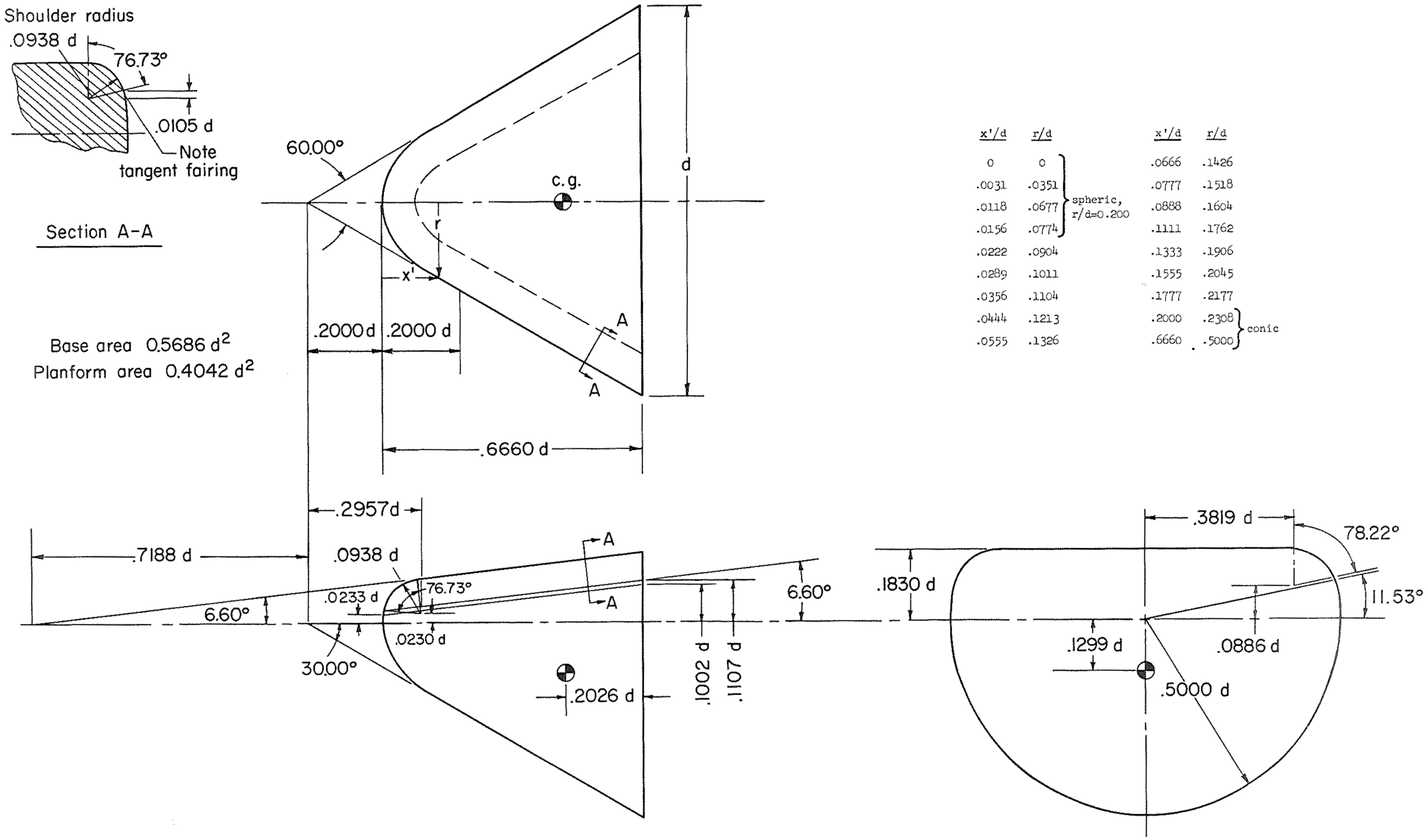
Figure 1.- Schematic sketch of the Ames 3.5-Foot Hypersonic Wind Tunnel.



A-29008

Figure 2.- Test section of the Ames 3.5-Foot Hypersonic Wind Tunnel.

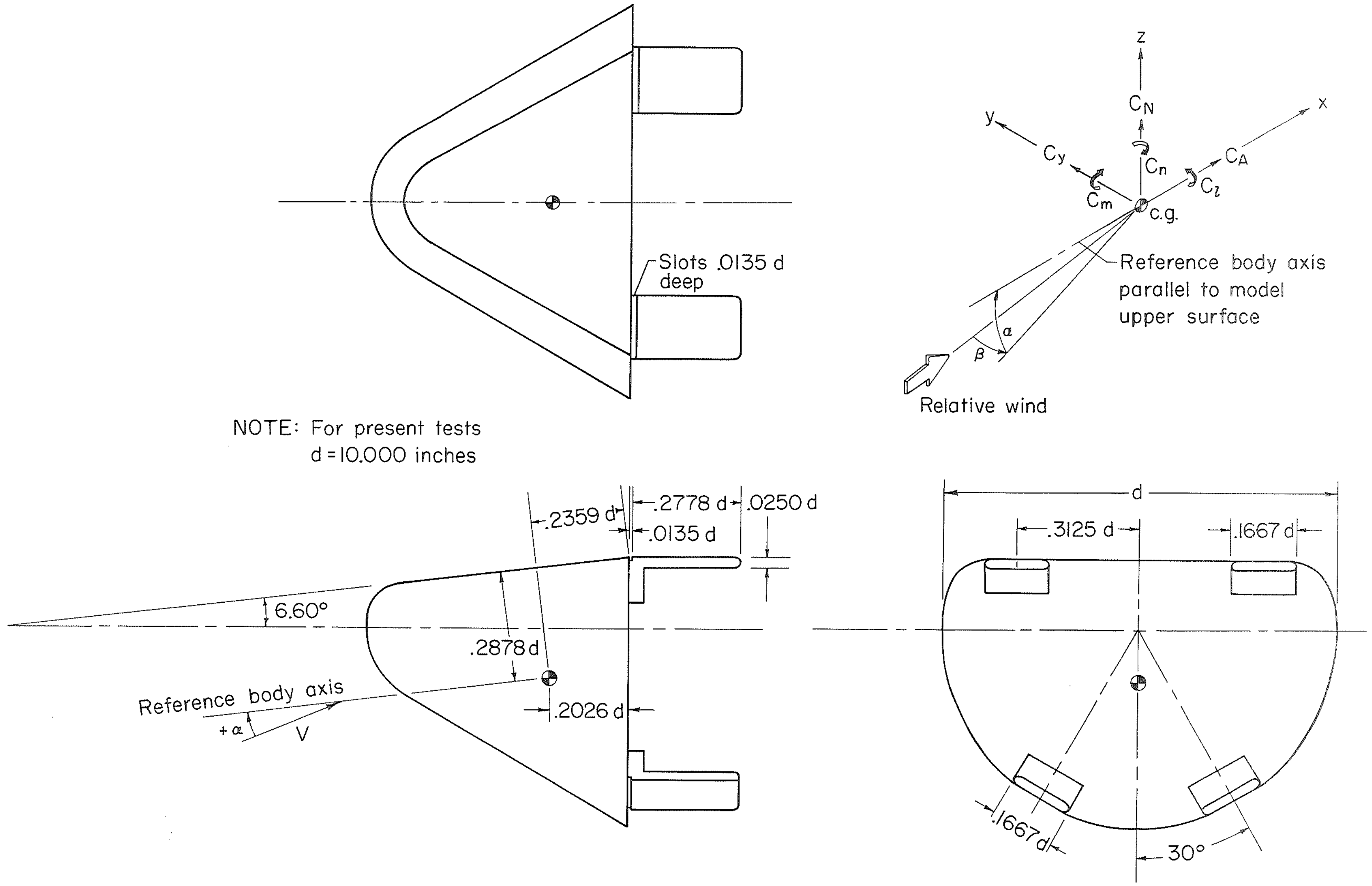
CONFIDENTIAL



x'/d	r/d		x'/d	r/d	
0	0	spheric, r/d=0.200	.0666	.1426	
.0031	.0351		.0777	.1518	
.0118	.0677		.0888	.1604	
.0156	.0774		.1111	.1762	
.0222	.0904		.1333	.1906	
.0289	.1011		.1555	.2045	
.0356	.1104		.1777	.2177	
.0444	.1213		.2000	.2308	conic
.0555	.1326		.6660	.5000	

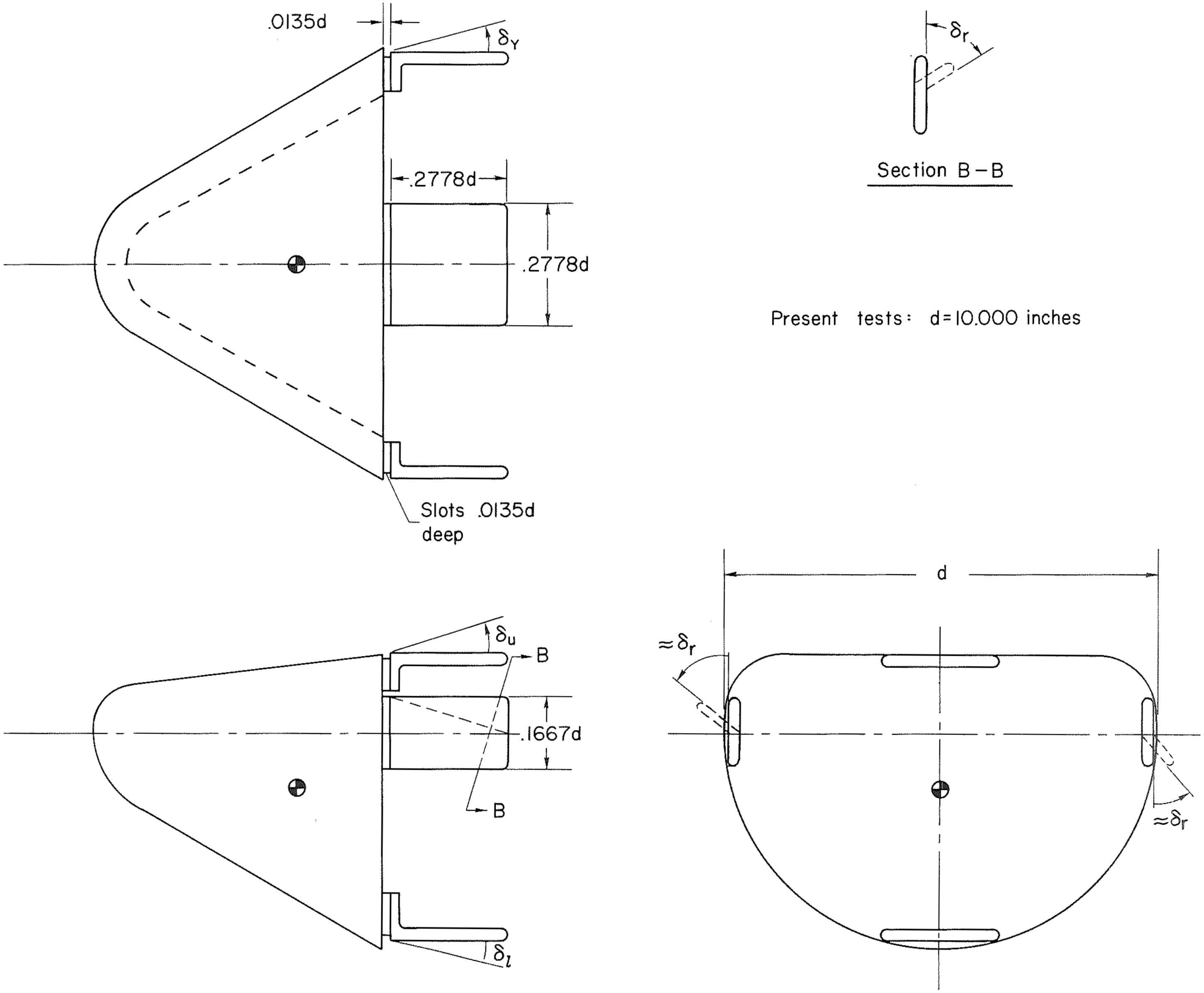
Present tests: d = 10.000 inches

Figure 3.- Dimensions of the basic M-1 body.



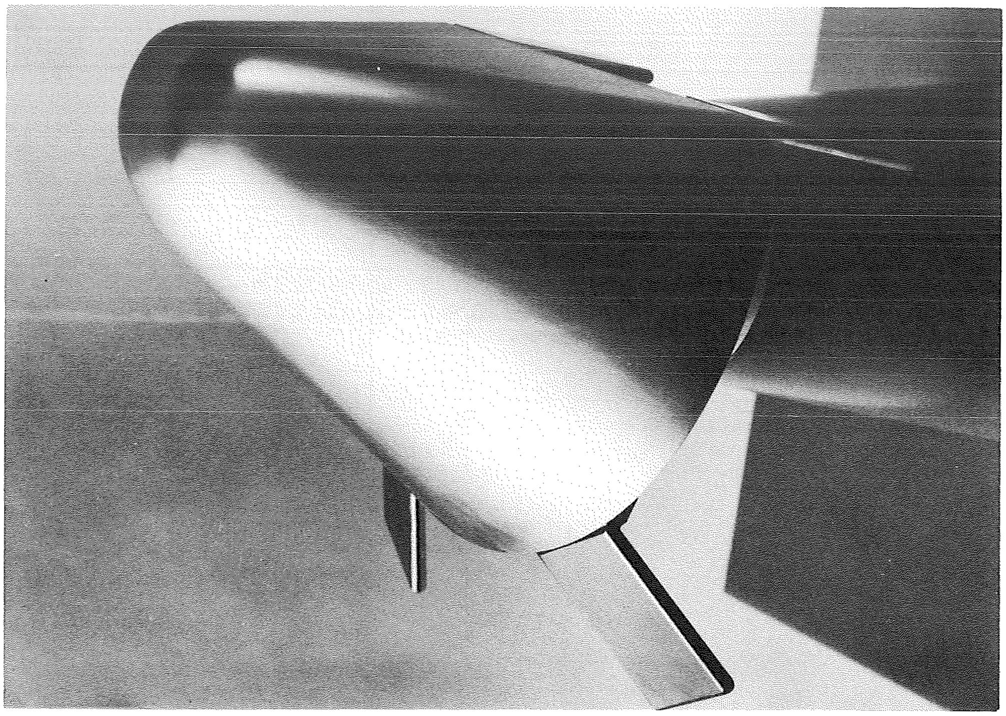
(a) Control set I.

Figure 4.- Dimensions of the control sets tested.



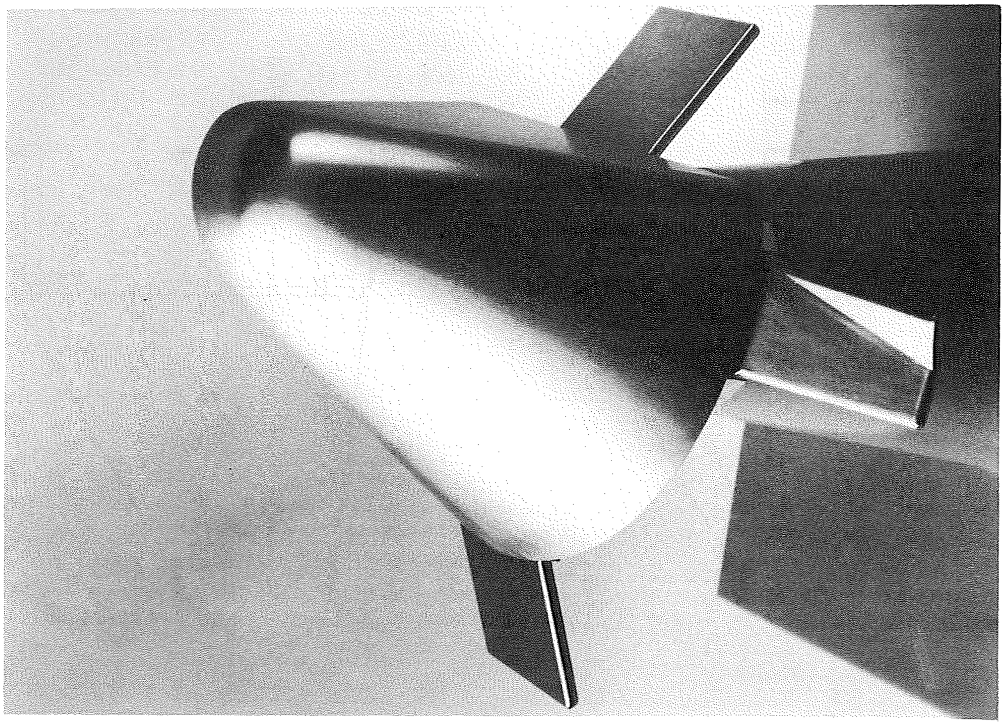
(b) Control set II, modified to have roll control.

Figure 4.- Concluded.



A-27680-7

(a) Control set I, body length 6.66 in.



A-27680-1

(b) Control set II, with roll flap; body length 6.66 in.

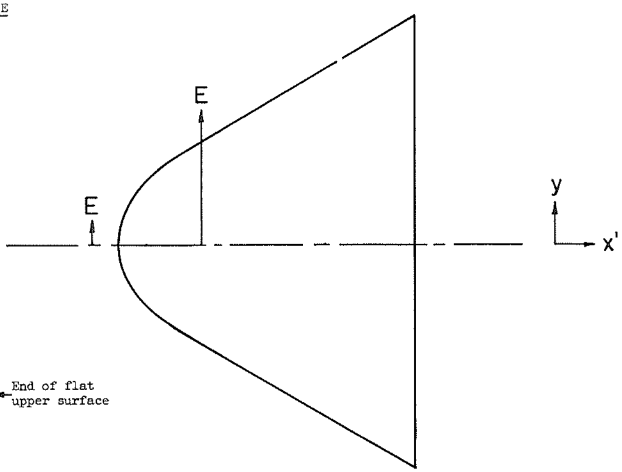
Figure 5.- Basic body with various flap configurations.

CO-ORDINATES THROUGH SECTION E-E

SET I

x'	z'
0.100	0.000
0.114	0.223
0.129	0.357
0.157	0.493
0.214	0.643
0.287	0.768
0.429	0.928
0.572	1.043
0.786	1.114
0.857	1.137
1.000	1.154

End of flat upper surface

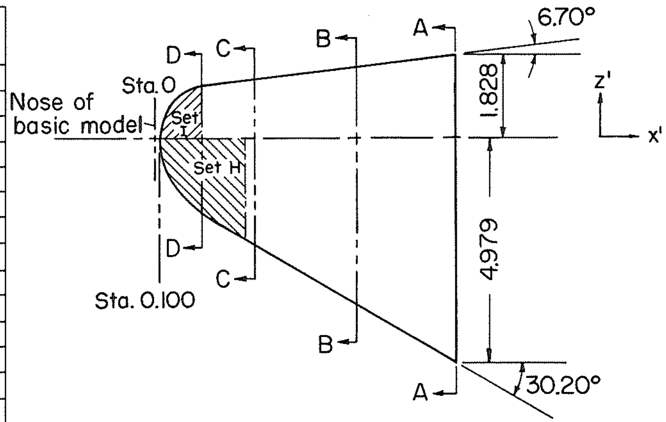


UPPER QUADRANT CO-ORDINATES

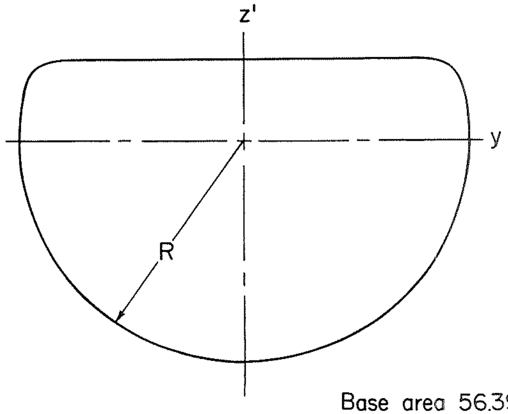
VIEW A-A		SECTION B-B		SECTION C-C		SECTION D-D	
STA.6.660 "R"=4.979		STA.4.426 "R"=3.679		STA.2.200 "R"=2.379		STA.1.000 "R"=1.621	
± y	z'	± y	z'	± y	z'	± y	z'
0.000	1.823	0.000	1.560	0.000	1.298	0.000	1.154
2.429	"	1.286	"	0.571	"	0.429	"
3.812	"	2.535	"	1.260	"	0.575	"
3.950	1.810	2.786	1.532	1.529	1.262	0.850	1.108
4.242	1.735	2.857	1.514	1.643	1.228	1.000	1.051
4.395	1.658	3.000	1.462	1.714	1.201	1.143	0.975
4.545	1.556	3.143	1.386	1.857	1.127	1.286	0.866
4.705	1.389	3.286	1.281	2.000	1.026	1.430	0.710
4.786	1.265	3.404	1.165	2.129	0.901	1.465	0.662
4.865	1.054	3.479	1.060	2.221	0.768	1.497	0.610
4.902	0.855	3.536	0.949	2.271	0.674	1.526	0.542
4.926	0.714	3.571	0.857	2.311	0.557	1.571	0.415
4.943	0.586	3.603	0.735	2.340	0.412	1.600	0.262
4.969	0.318	3.664	0.308	2.357	0.290	1.614	0.159
4.979	0.000	3.679	0.000	2.379	0.000	1.621	0.000

SET H

x'	z'
.100	0.000
0.129	-0.357
0.160	-0.493
0.214	-0.679
0.250	-0.771
0.293	-0.857
0.360	-0.965
0.420	-1.057
0.500	-1.150
0.621	-1.286
0.711	-1.376
0.814	-1.471
0.929	-1.571
1.139	-1.721
1.325	-1.857
1.560	-2.000
1.785	-2.138
1.980	-2.257



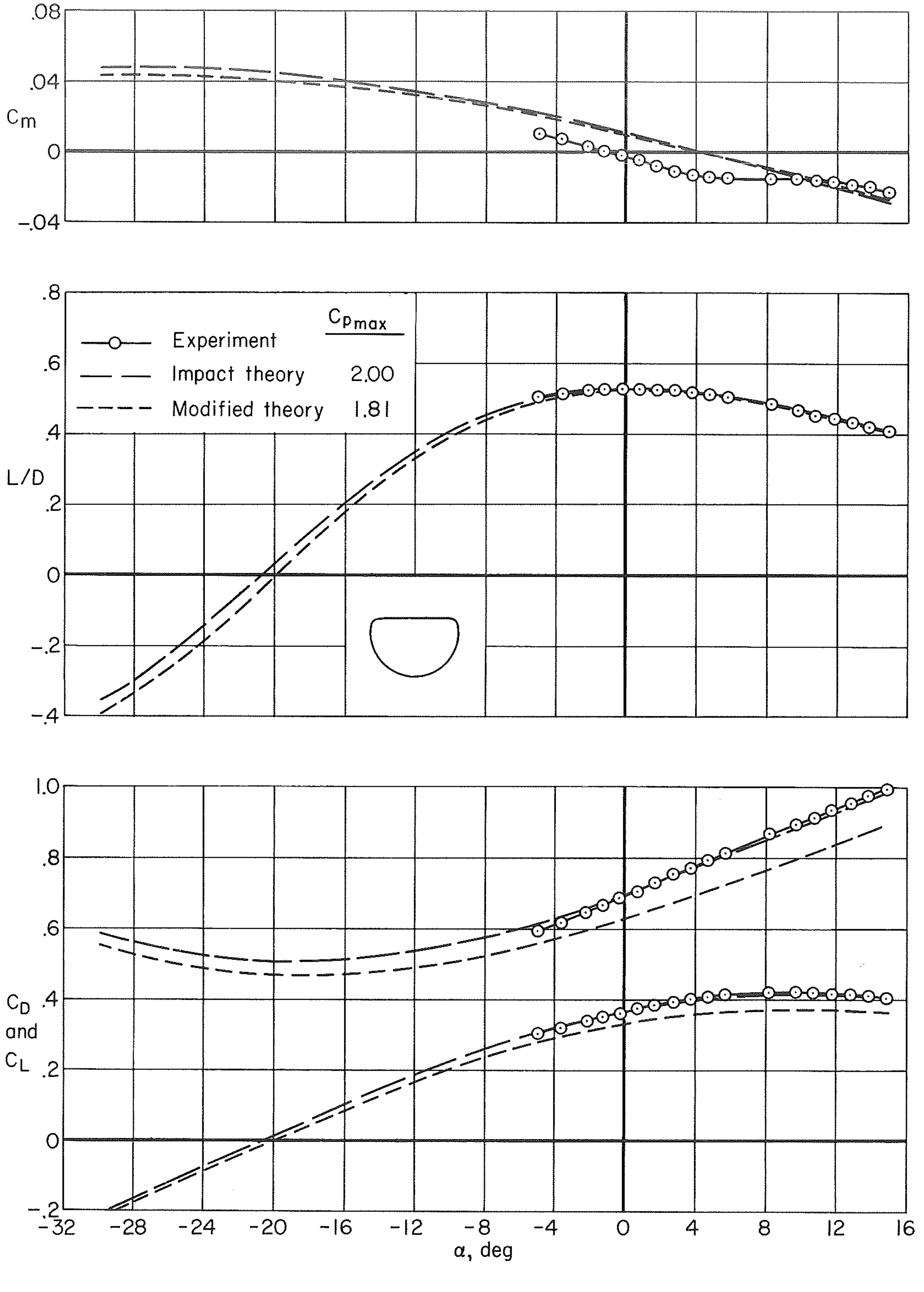
NOTE: All dimensions in inches



Base area 56.39 sq. in.
Planform area 39.62 sq. in.

Figure 6.- Dimensions of the ablated body.

[redacted]

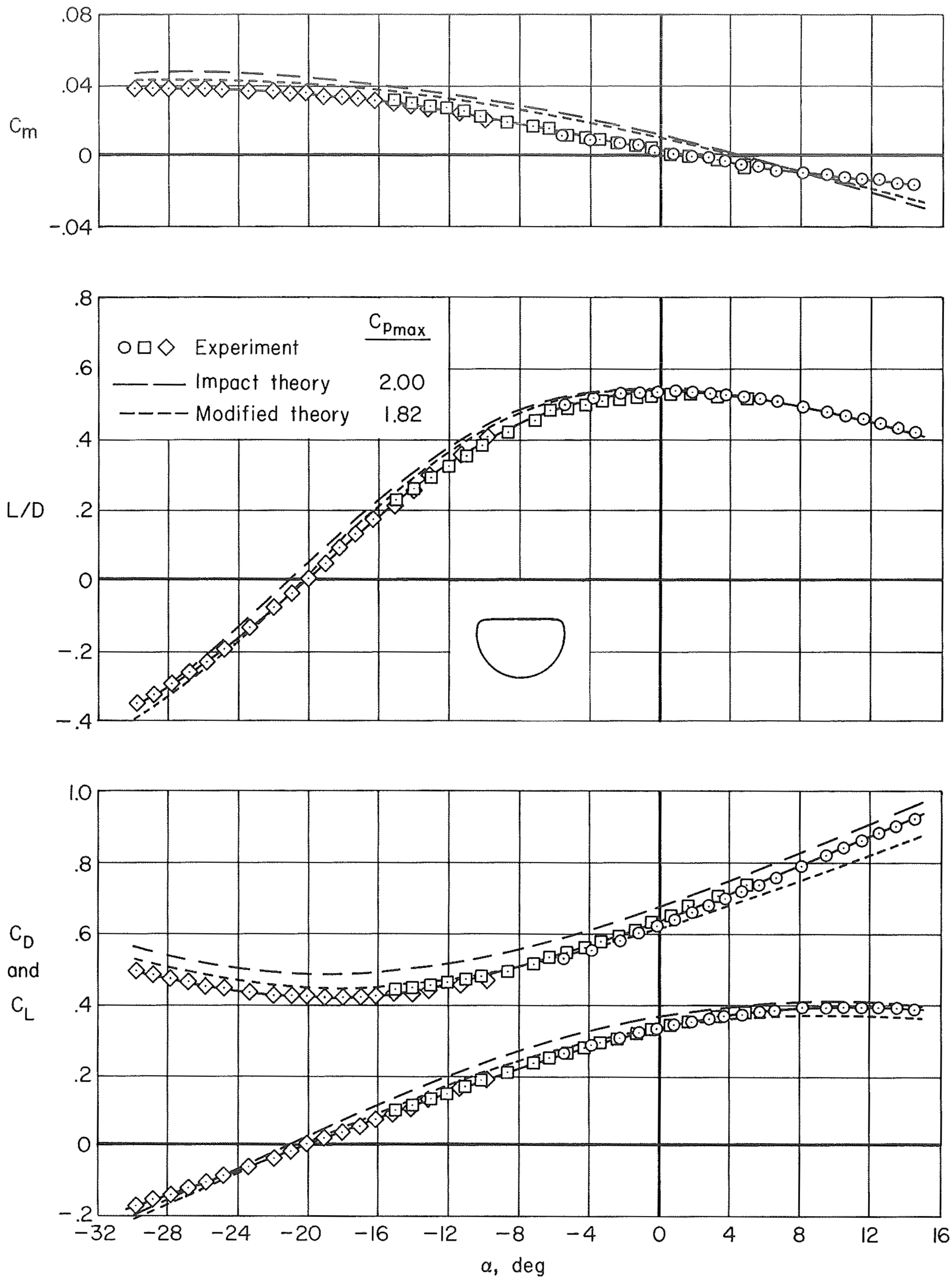


(a) M = 5.2

Figure 7.- Longitudinal aerodynamic characteristics of the basic body without flaps.

[redacted]

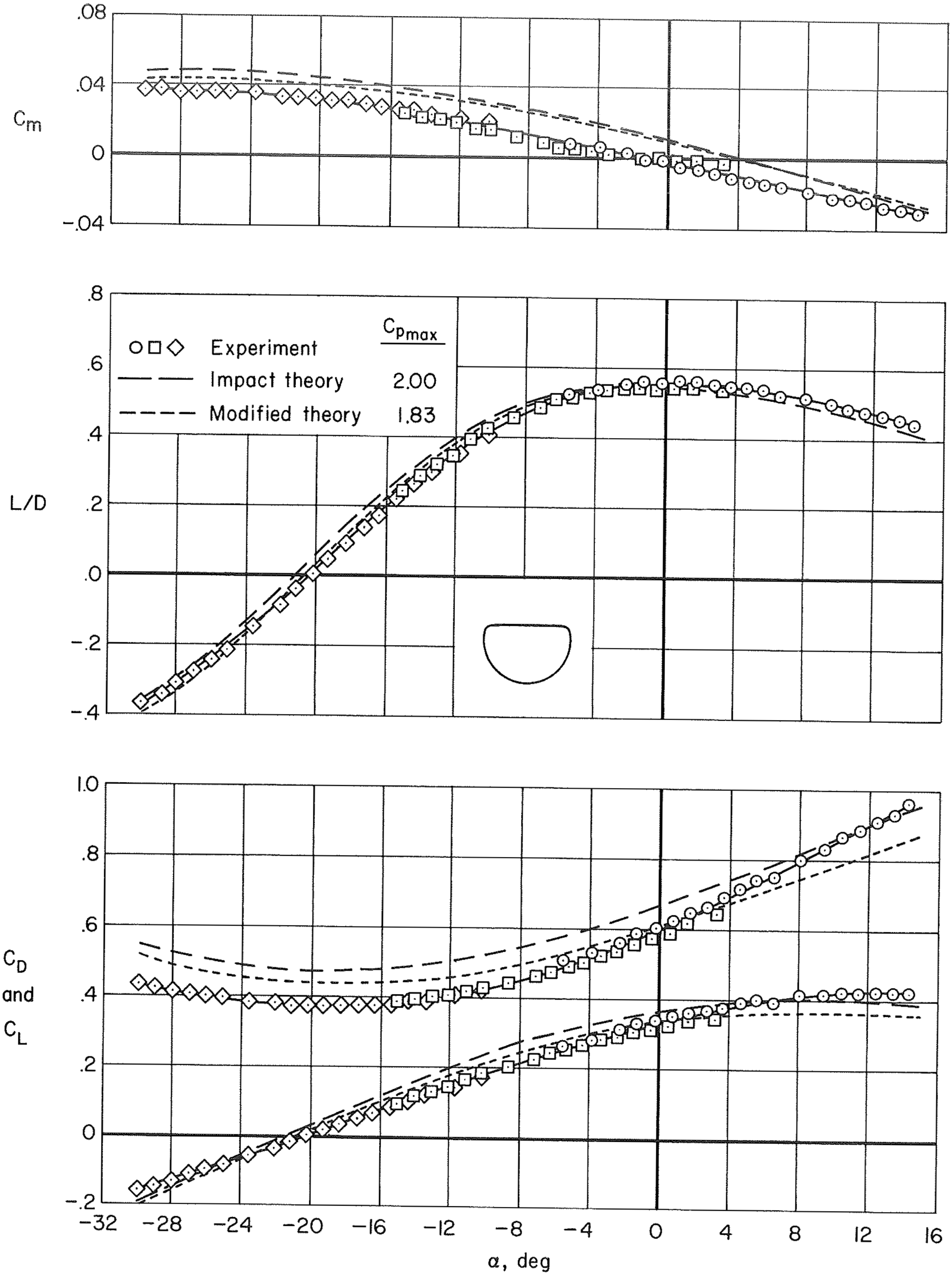
[redacted]



(b) M = 7.4

Figure 7.- Continued.

[redacted]



(c) M = 10.4

Figure 7.- Concluded.

[redacted]

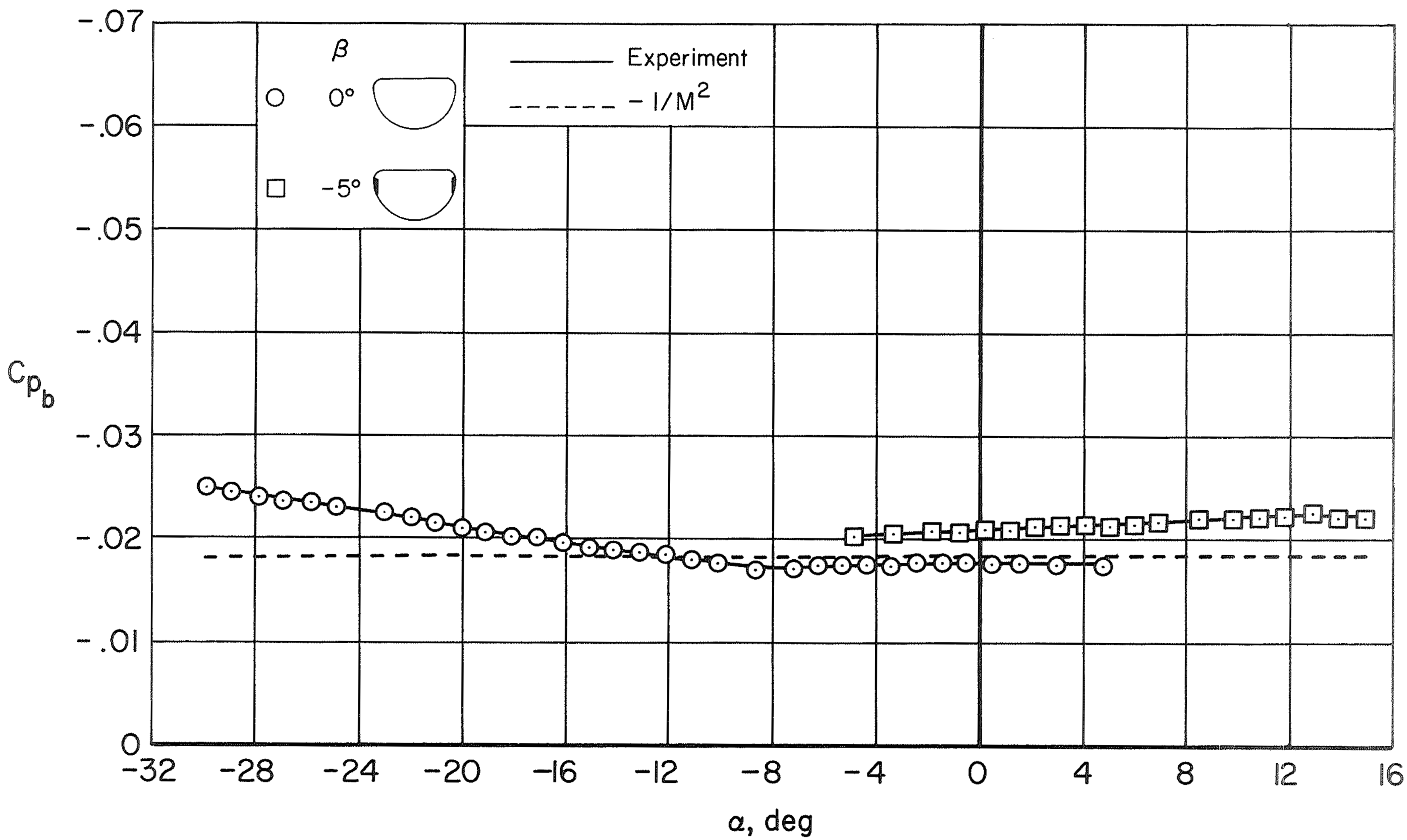
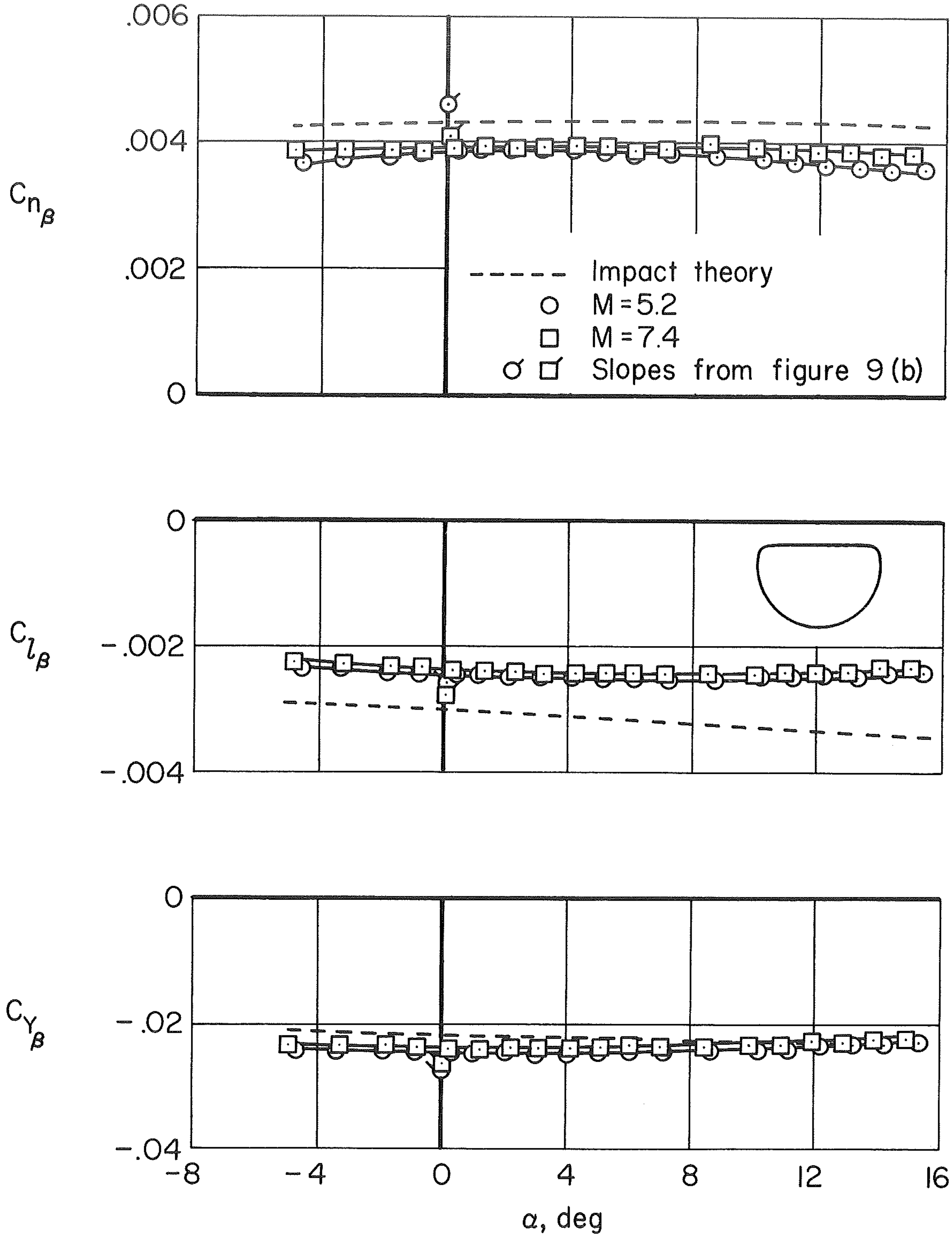


Figure 8.- Typical base-pressure coefficients for the basic body; $M = 7.4$.

[redacted]

[redacted]

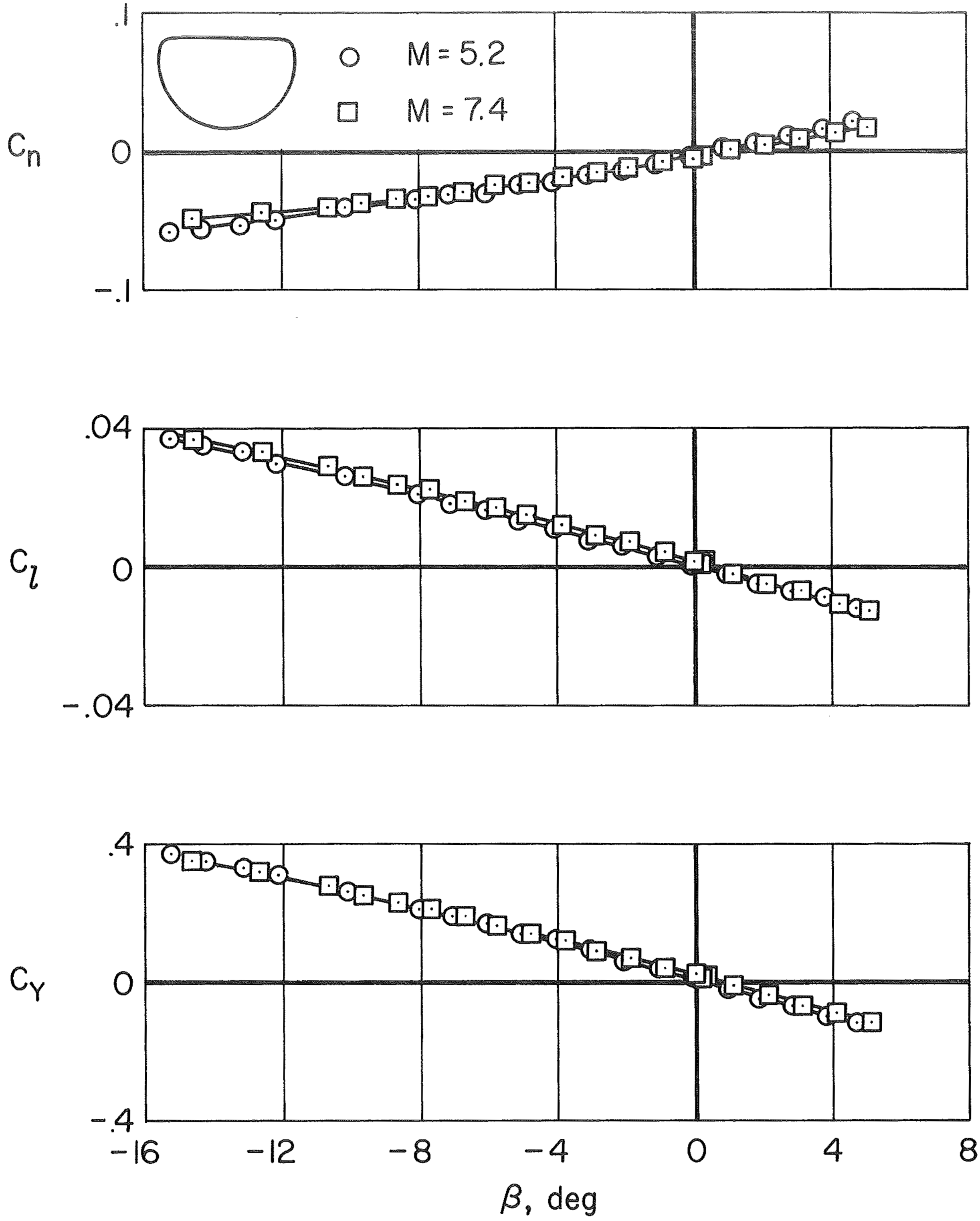


(a) C_{n_β}, C_{l_β}, and C_{Y_β}

Figure 9.- Lateral and directional characteristics for the basic body at Mach numbers of 5.2 and 7.4.

[redacted]

[redacted]



(b) C_n, C_l, and C_Y at $\alpha = 0^{\circ}$

Figure 9.- Concluded.

[redacted]

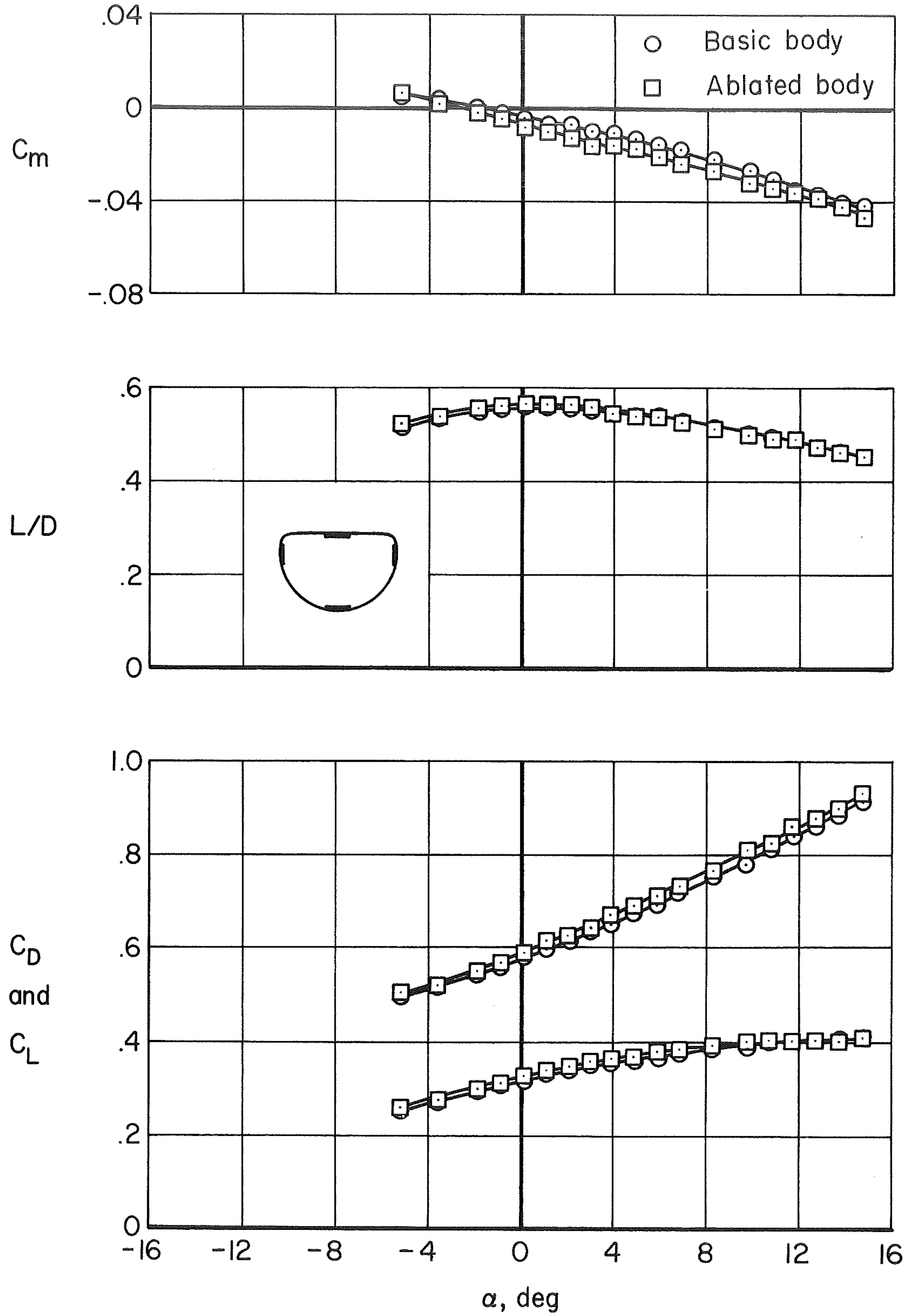


Figure 10.- Effect of ablation on the longitudinal aerodynamic characteristics of the basic body with control set II undeflected; $M = 10.4$.

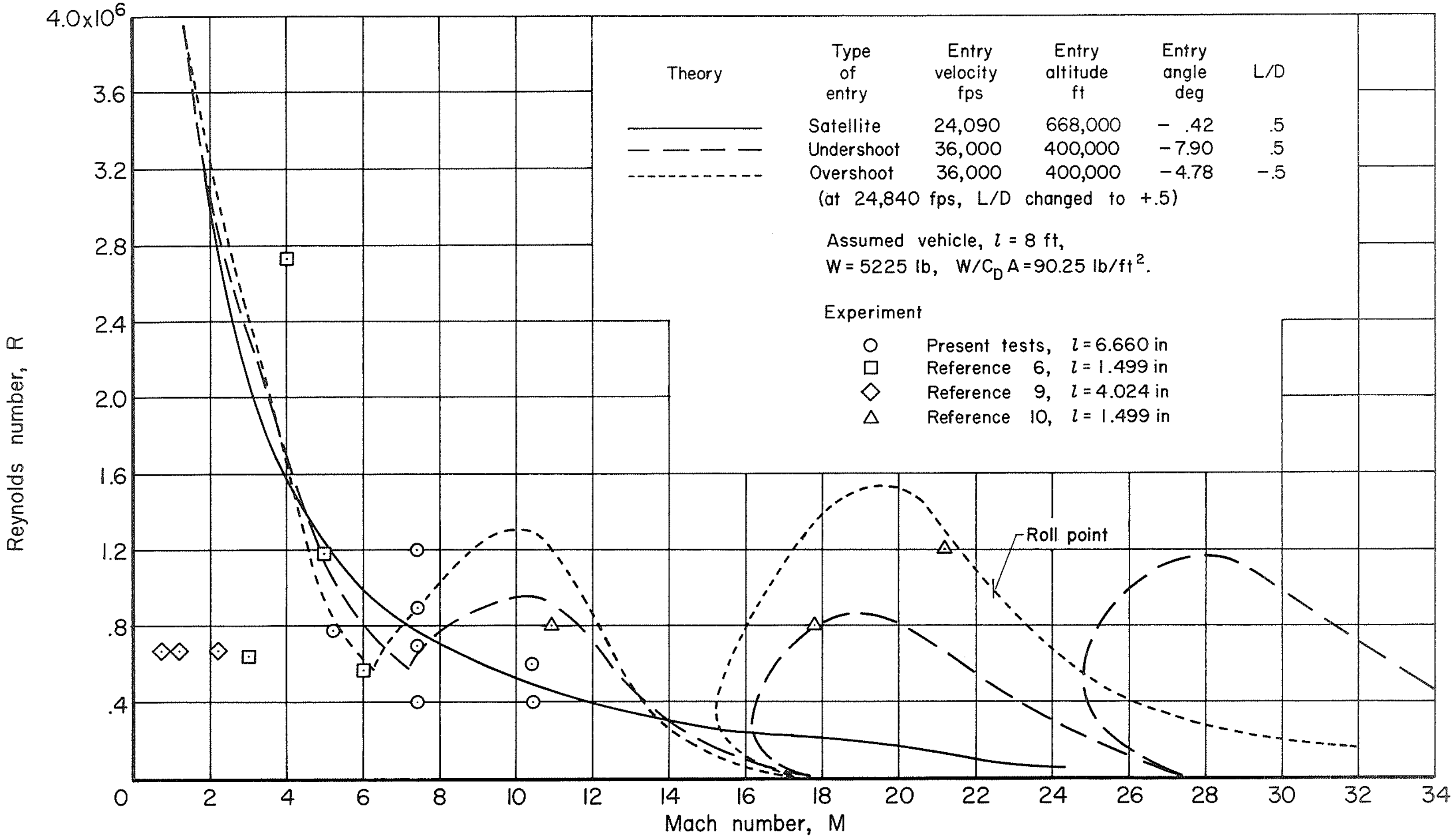


Figure 11.- Variation of Reynolds number with Mach number for the wind-tunnel tests and for a full-scale vehicle entering the Earth's atmosphere along three types of trajectories.

[redacted]

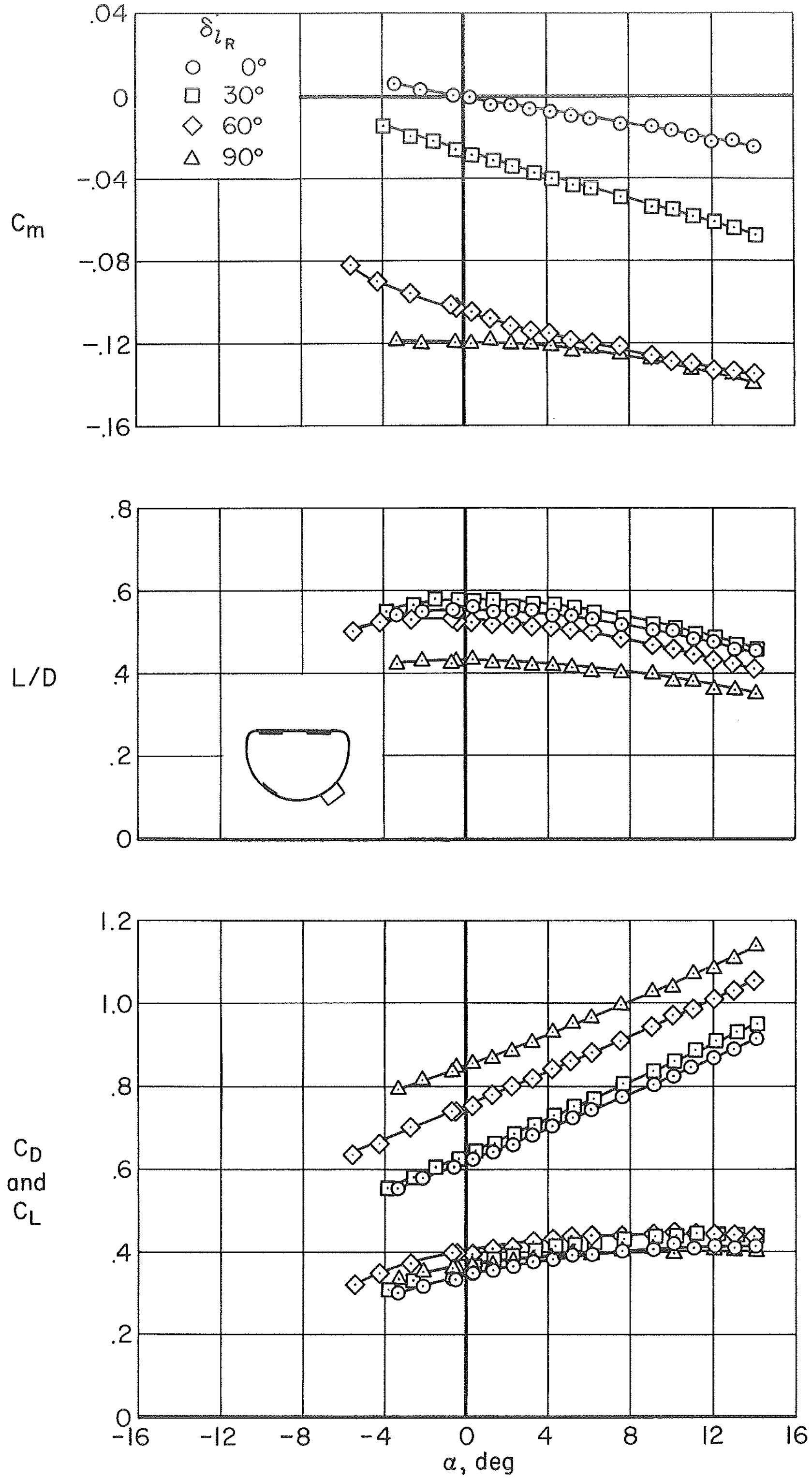
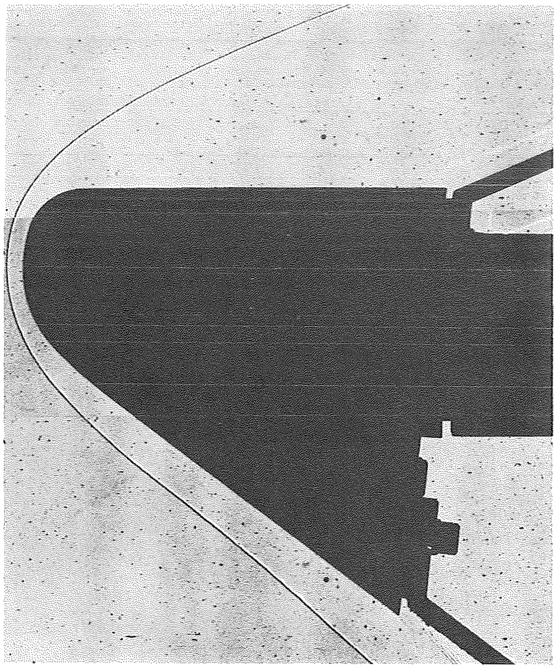


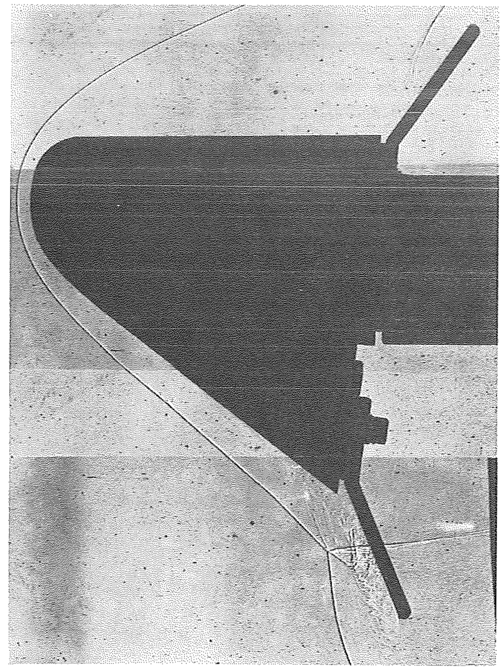
Figure 12.- Effect of lower-flap deflection on the longitudinal aerodynamic characteristics of the basic body with control set I, M = 7.4.

[redacted]

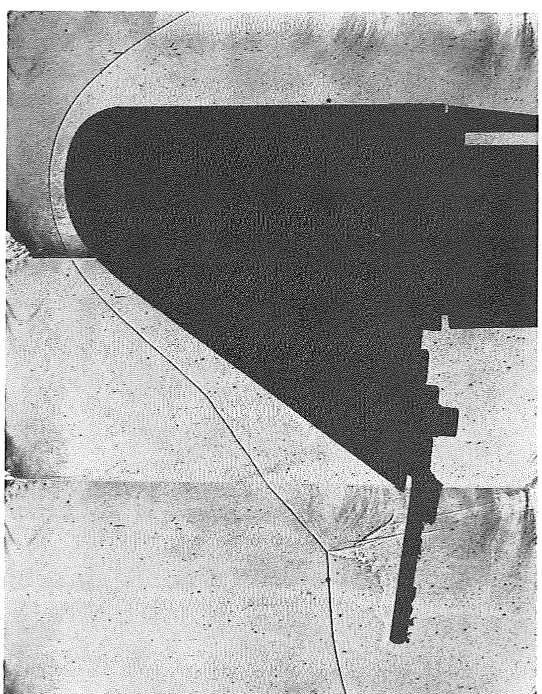
[redacted]



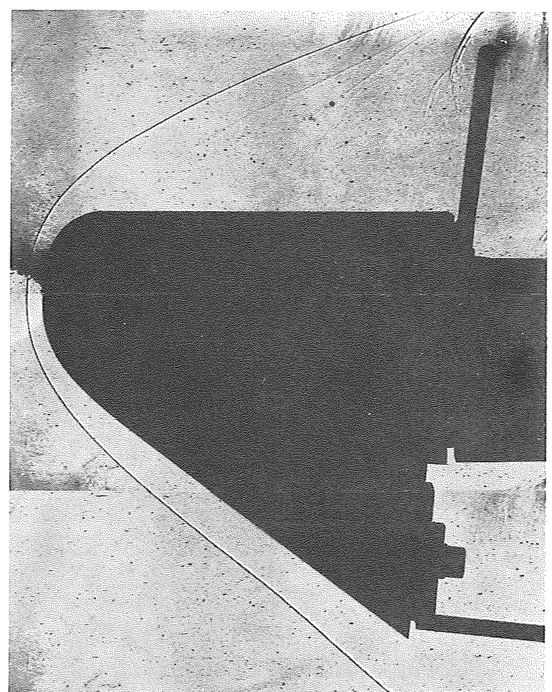
(a) $\delta_u = \delta_l = 30^\circ$ A-28173



(b) $\delta_u = \delta_l = 60^\circ$ A-28174



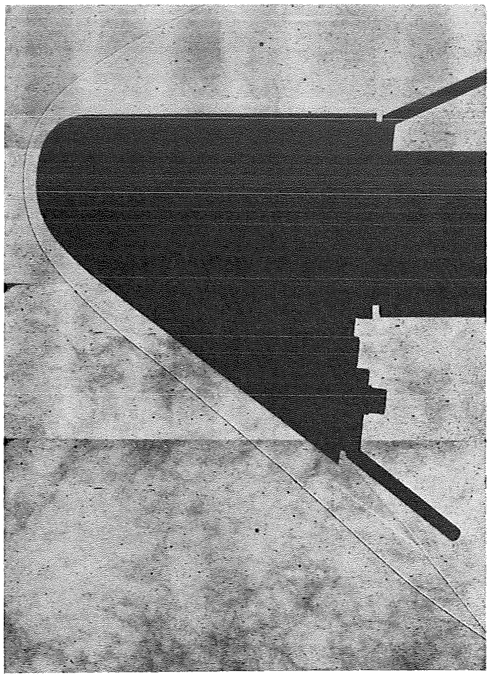
(c) $\delta_u = 0^\circ$, $\delta_l = 90^\circ$ A-28177



(d) $\delta_u = 90^\circ$, $\delta_l = 0^\circ$ A-28176

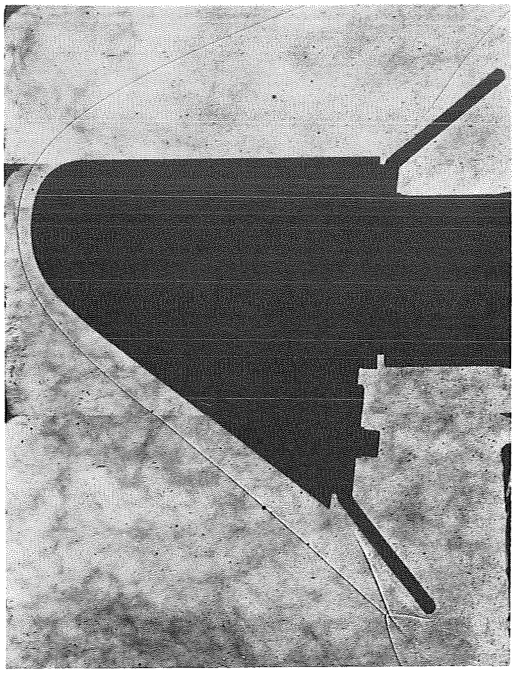
Figure 13.- Shadowgraph pictures of the basic body with control set II, M = 7.4.

[redacted]



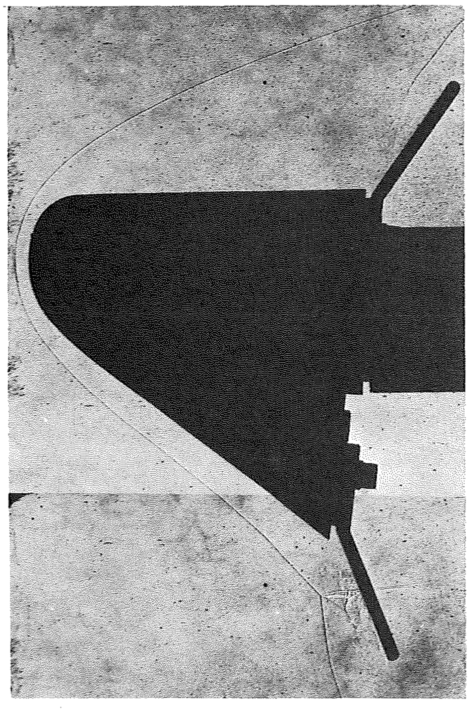
A-28597-1

(a) $\delta_u = \delta_l = 30^\circ$



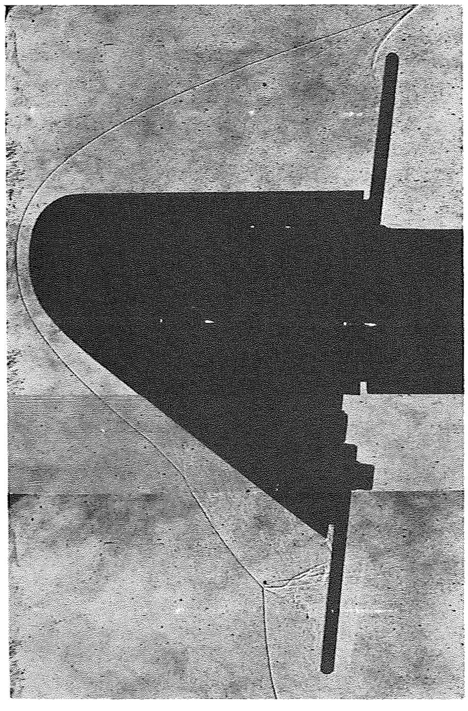
A-28597-2

(b) $\delta_u = \delta_l = 45^\circ$



A-28597-3

(c) $\delta_u = \delta_l = 60^\circ$



A-28597-4

(d) $\delta_u = \delta_l = 90^\circ$

Figure 14.- Shadowgraph pictures of the basic body with control set II, M = 10.4.

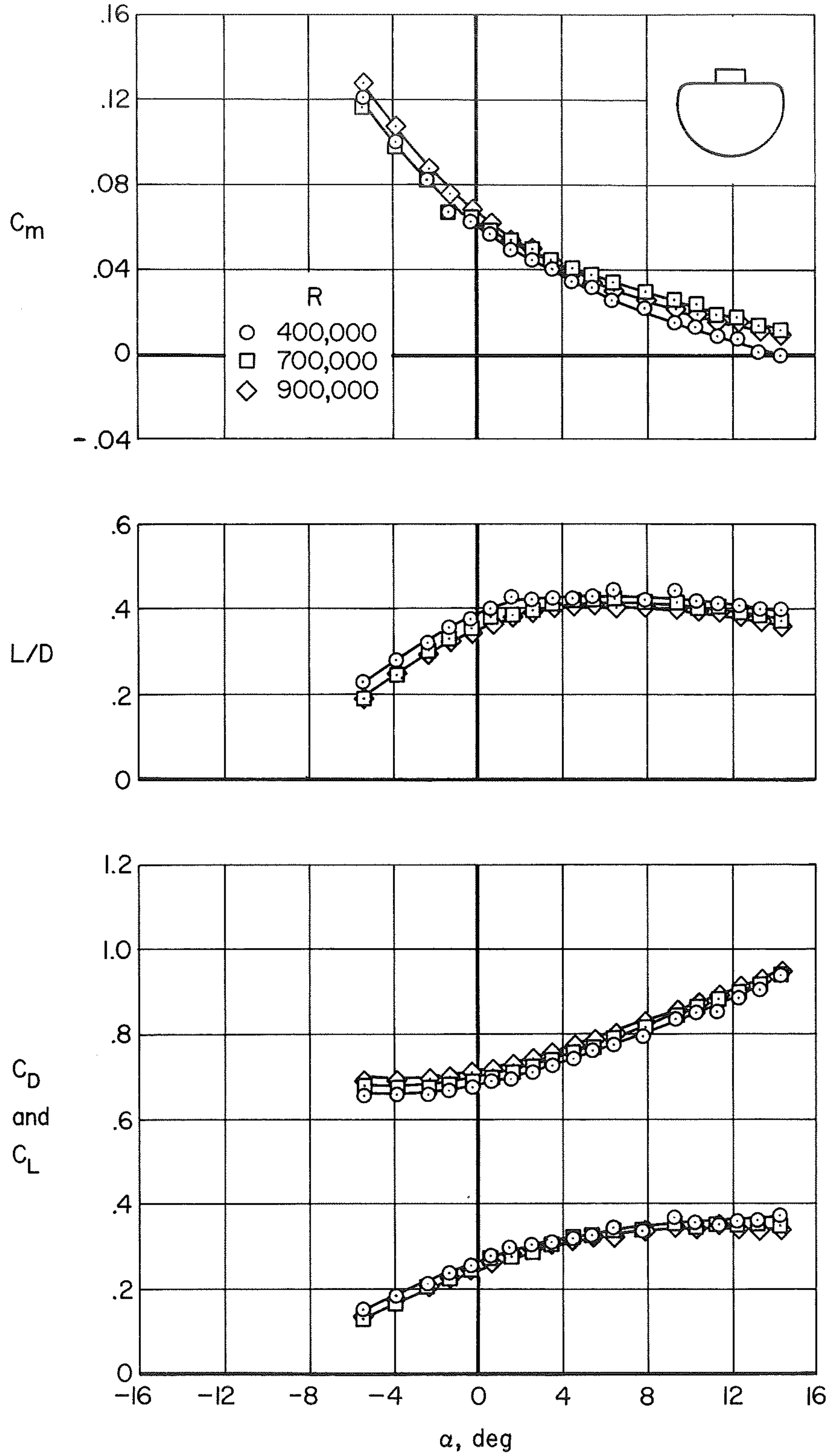
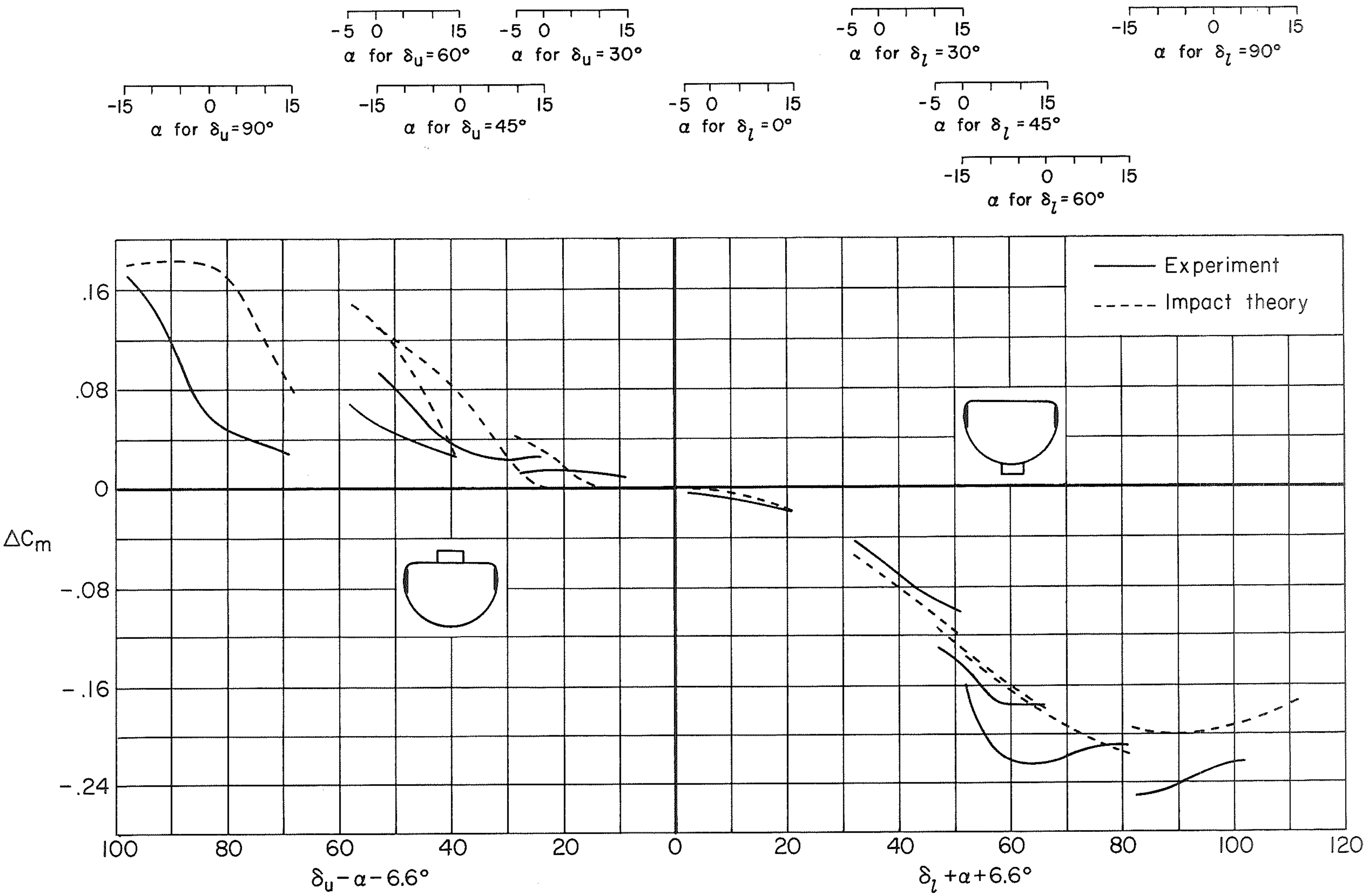
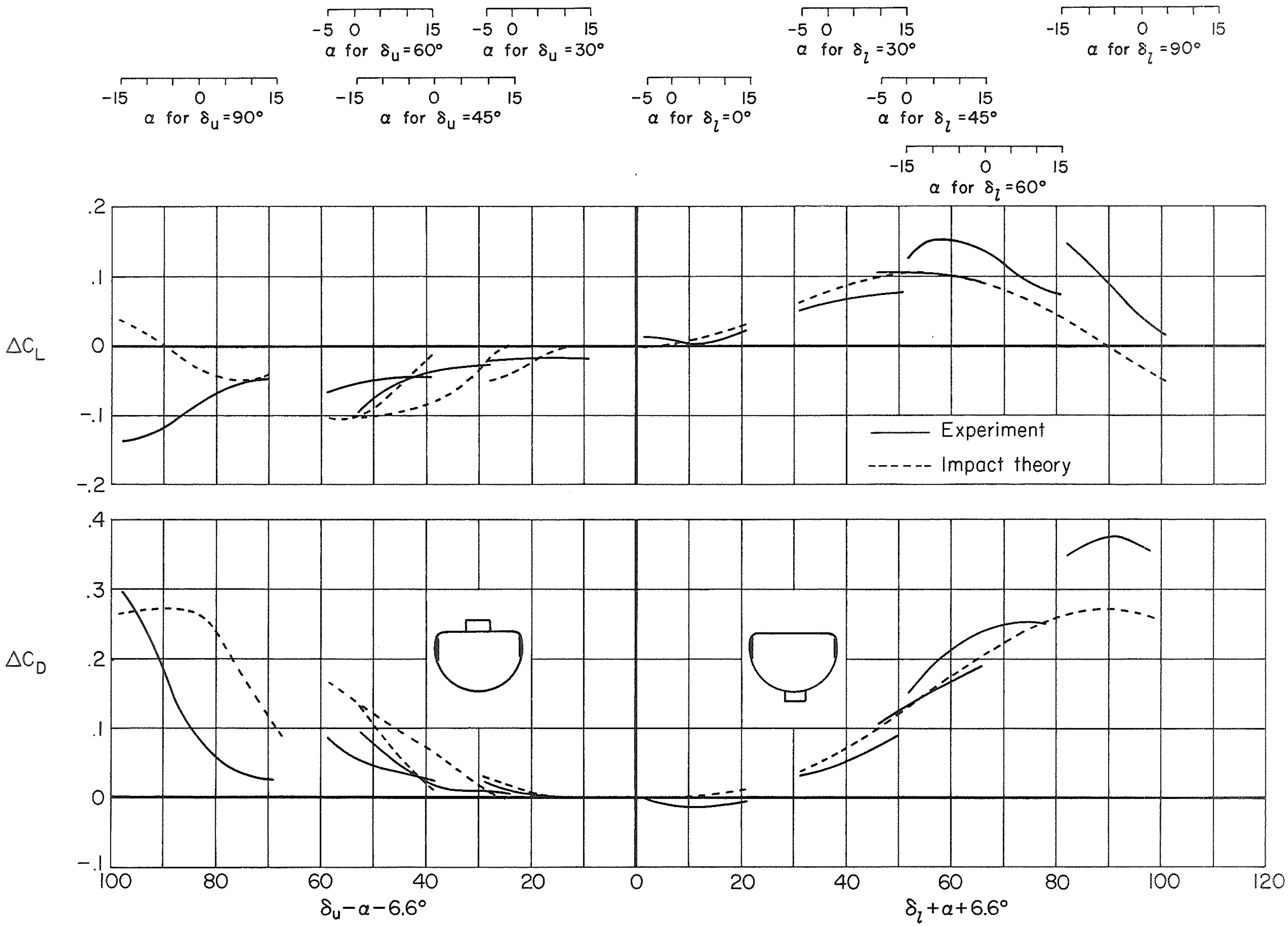


Figure 15.- Effect of Reynolds number on the longitudinal aerodynamic characteristics of the basic body with the upper flap of control set II deflected 90°; $M = 7.4$.



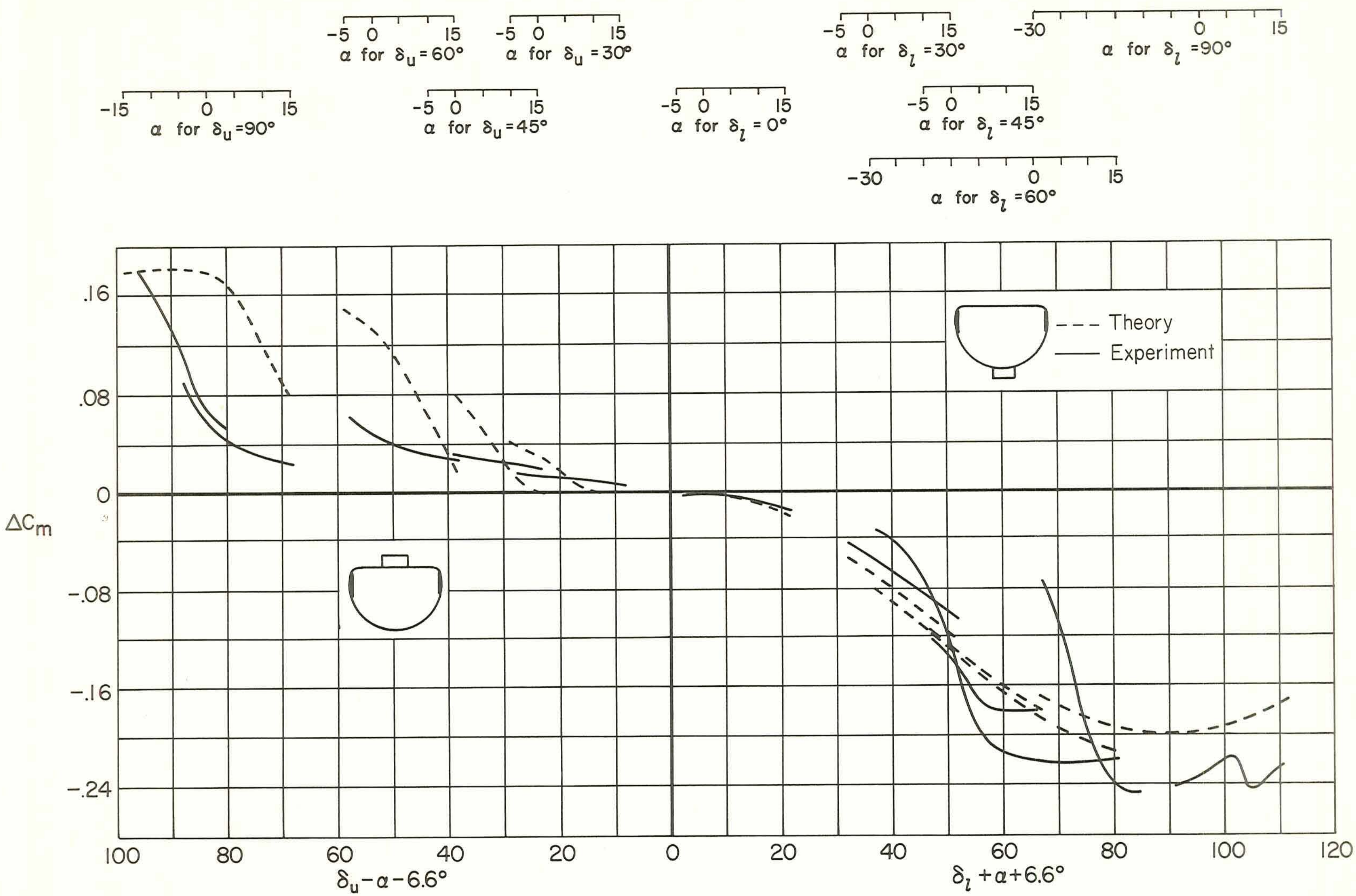
(a) ΔC_m, M = 7.4

Figure 16.- Pitching-moment-, lift-, and drag-coefficient increments due to pitch-flap deflections of control set II.



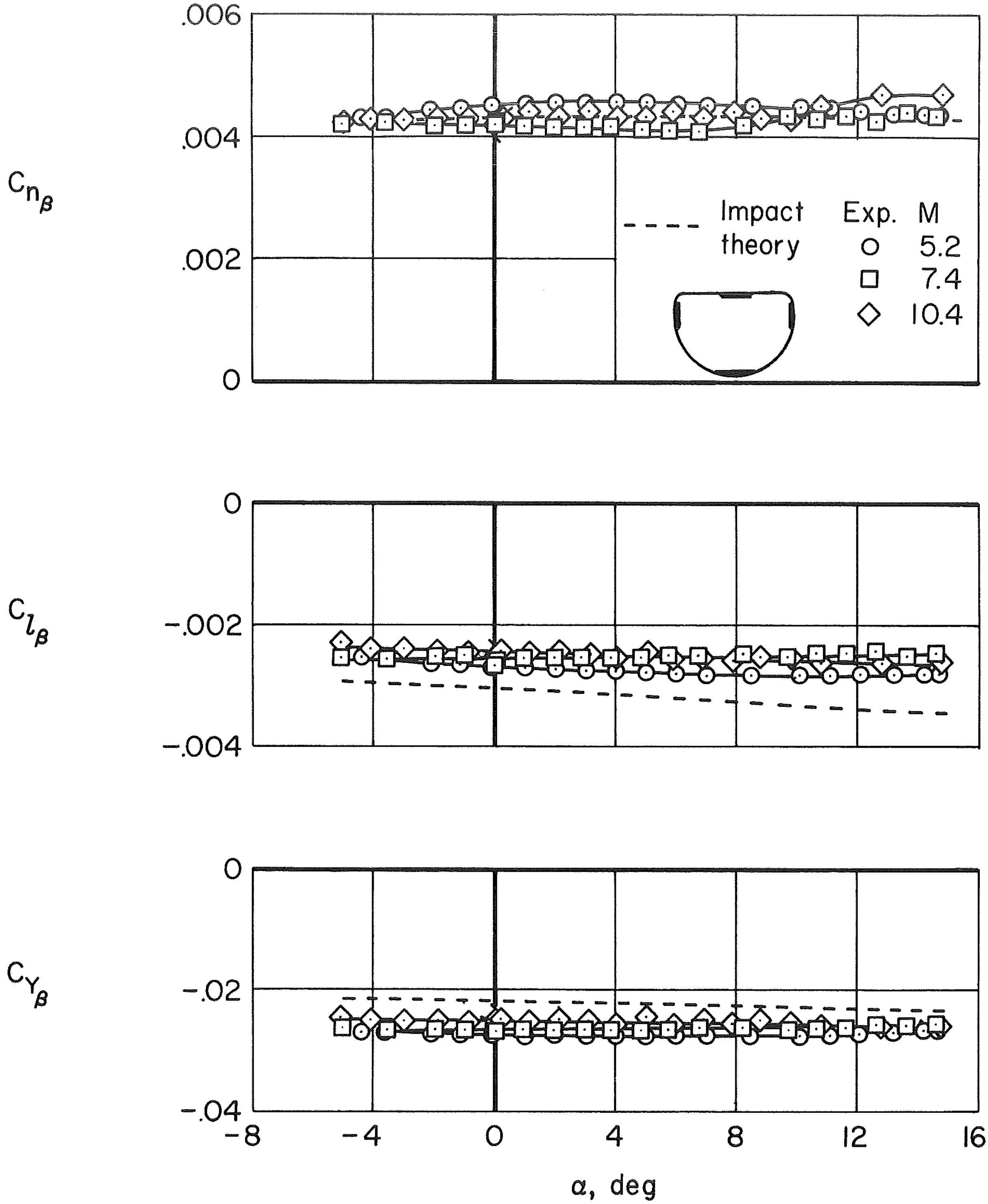
(b) ΔC_L and ΔC_D, M = 7.4

Figure 16.- Continued.



(c) ΔC_m, M = 10.4

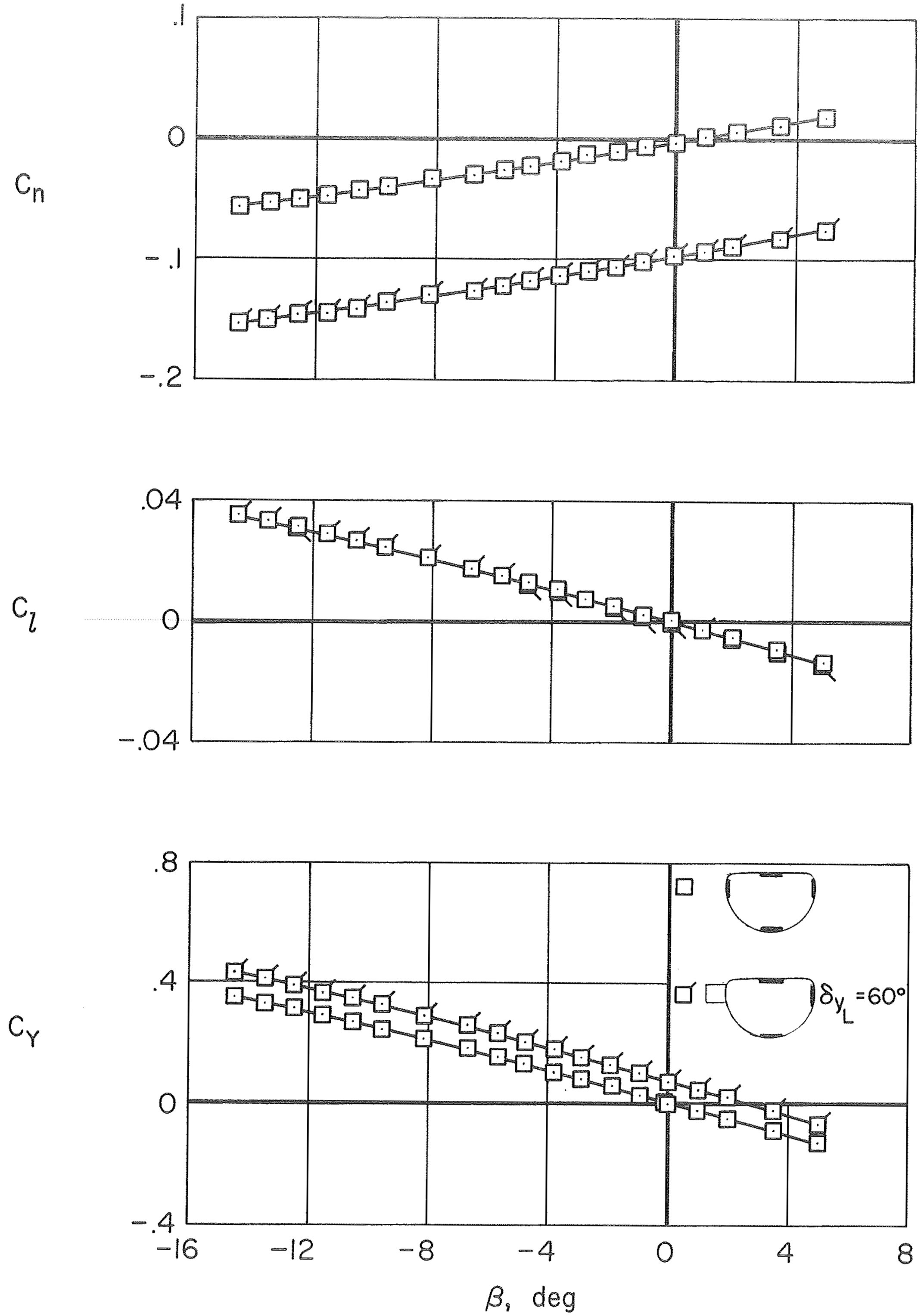
Figure 16.- Concluded.



(a) C_{n_β}, C_{l_β}, and C_{Y_β} at $M = 5.2$, 7.4, and 10.4

Figure 17.- Lateral and directional characteristics for the basic body with control set II.

[redacted]



(b) C_n, C_l, and C_Y at $\alpha = 0^\circ$ and $M = 7.4$

Figure 17.- Concluded

[redacted]

[redacted]

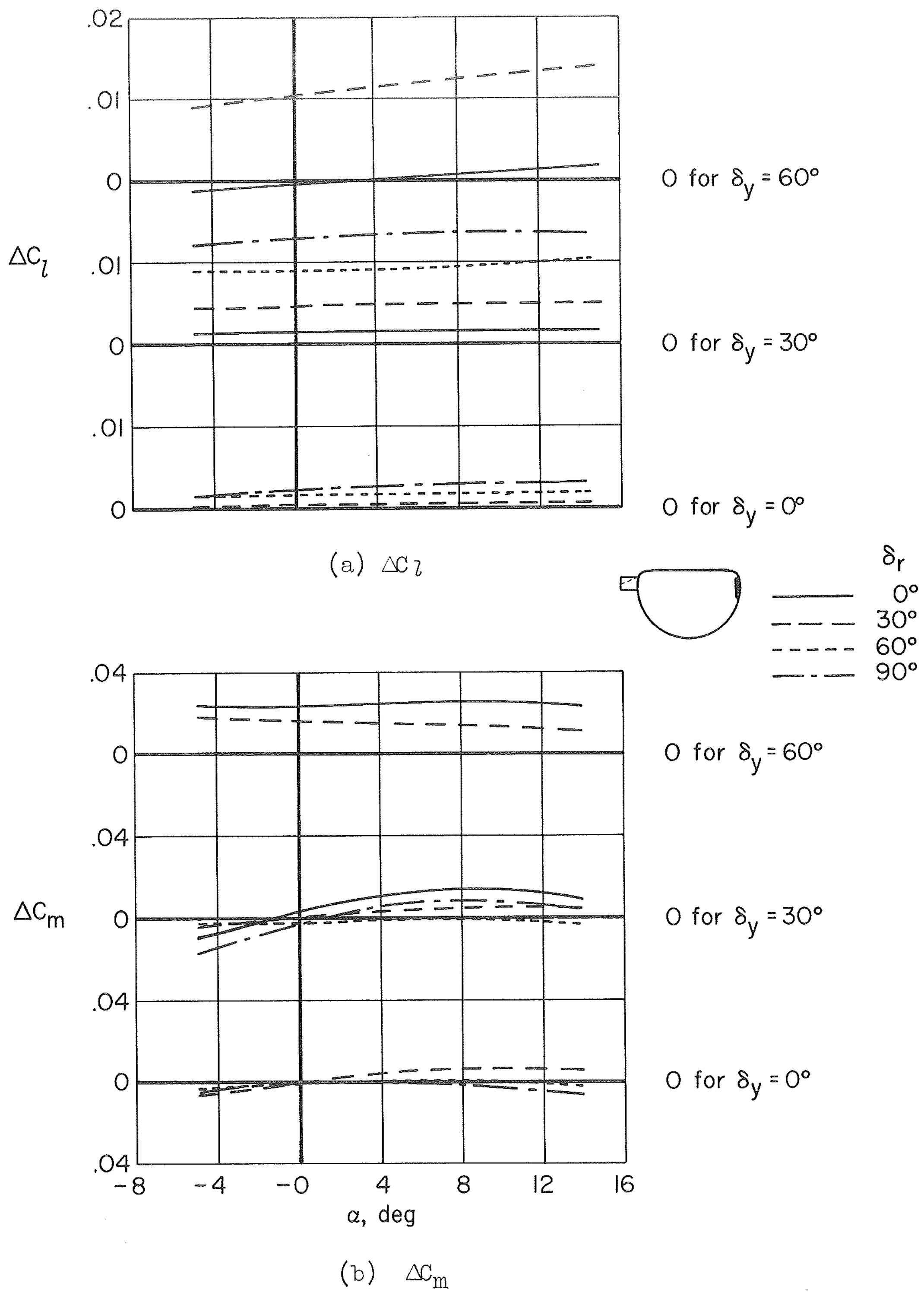
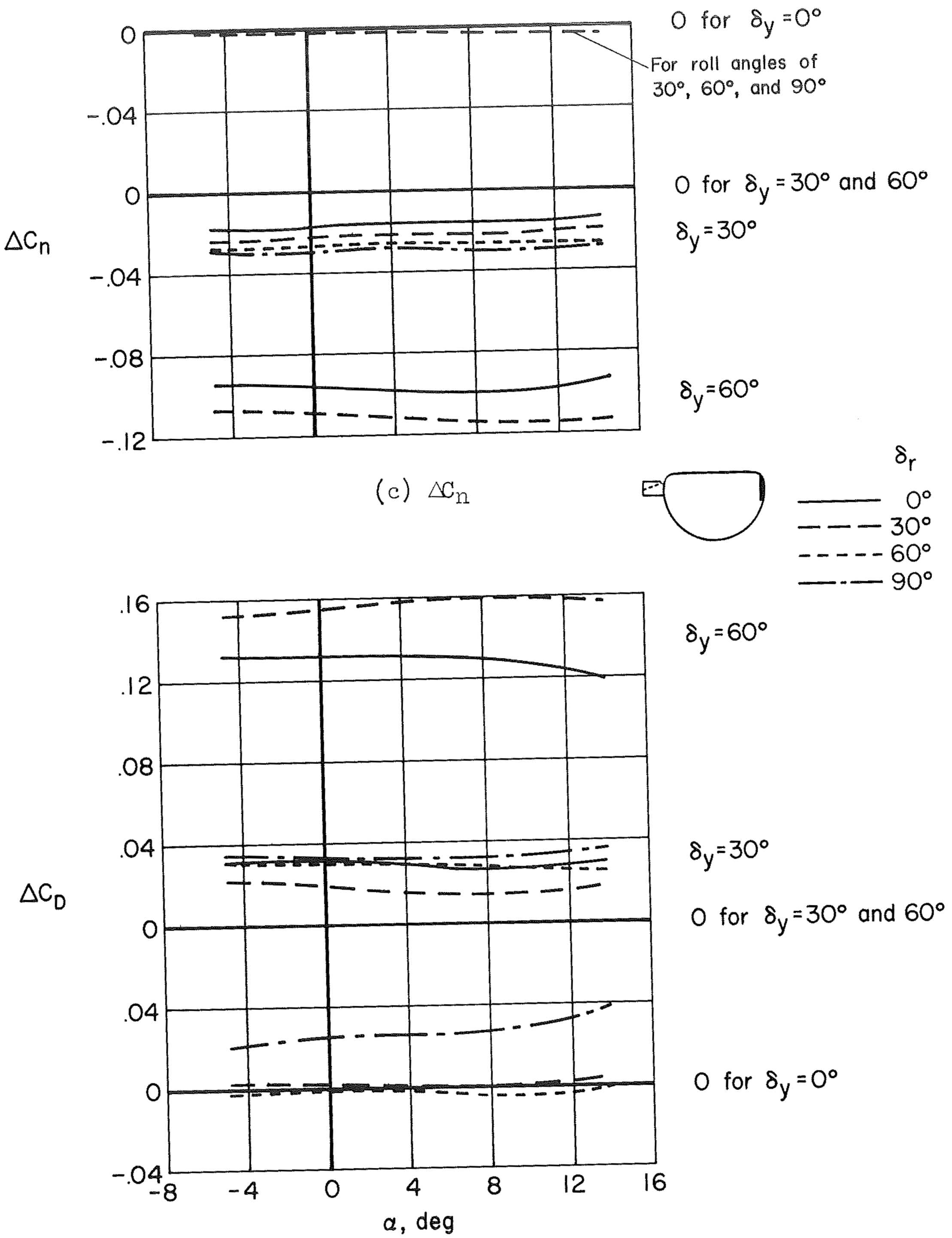


Figure 18.- Experimental increments in aerodynamic characteristics due to yaw and roll deflections of the left-side flap of control set II; M = 7.4.

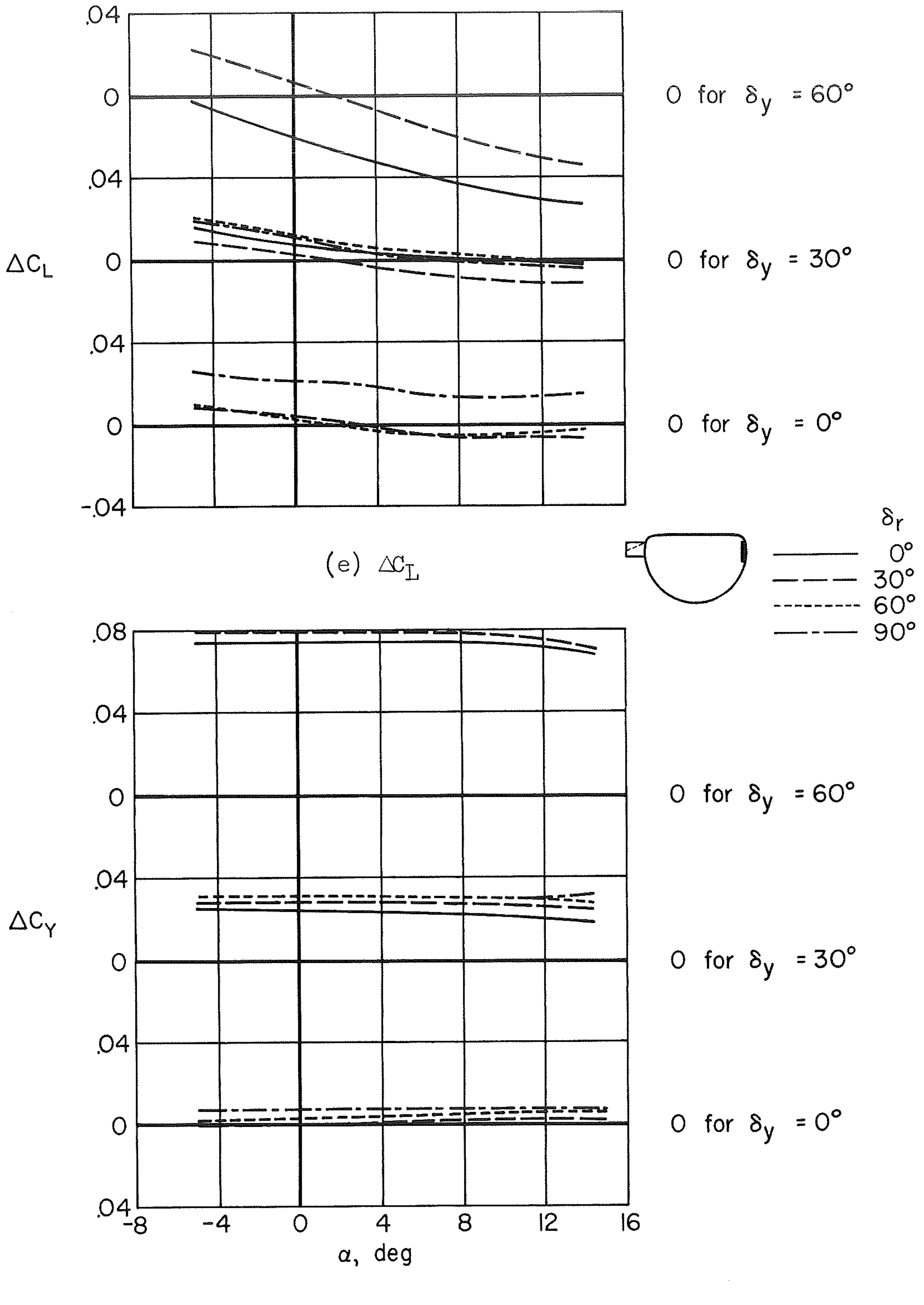
[redacted]



(c) ΔC_n

(d) ΔC_D

Figure 18.- Continued.



(e) ΔC_L

(f) ΔC_Y

Figure 18.- Concluded.

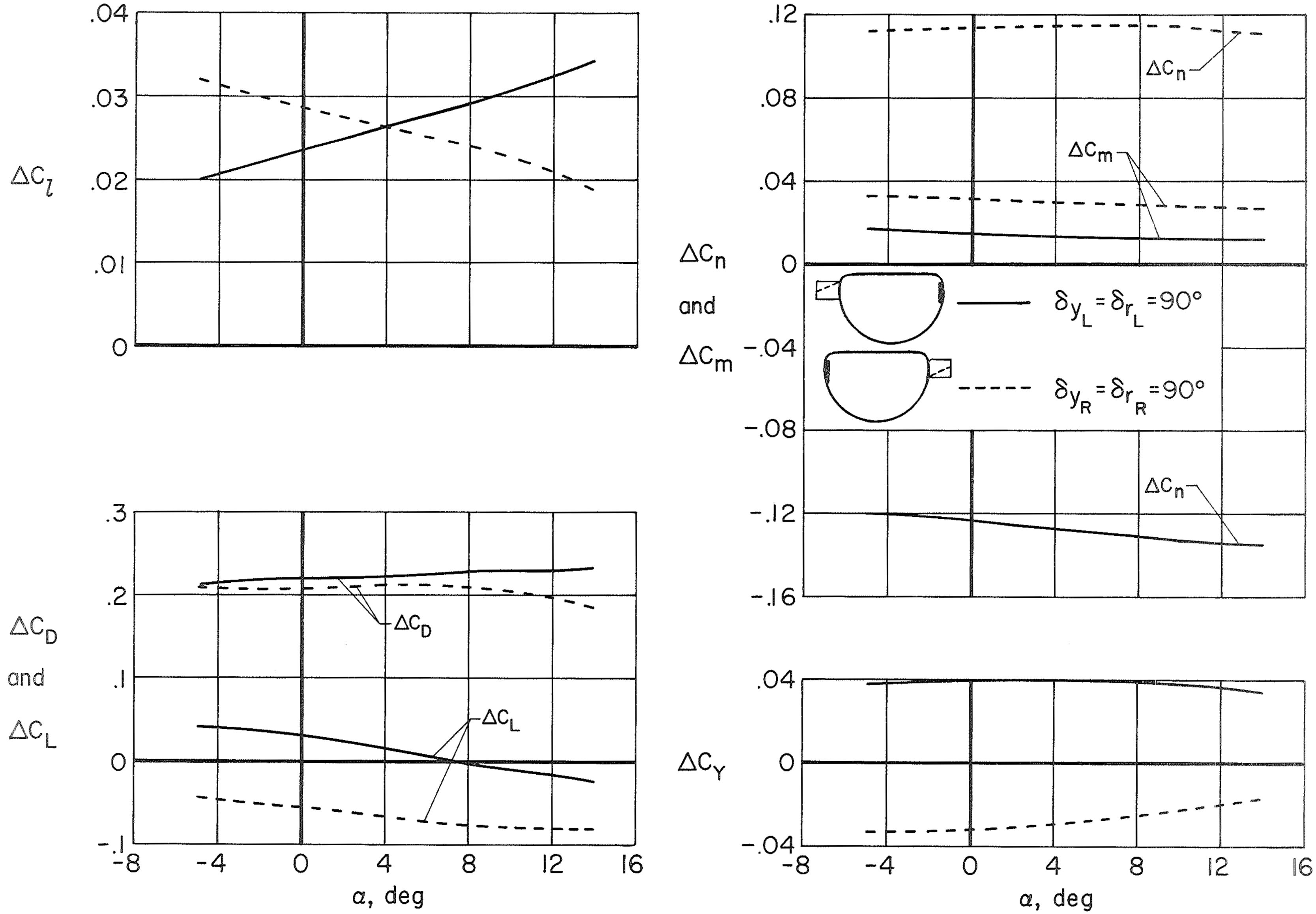


Figure 19.- Experimental increments in aerodynamic coefficients due to 90° deflections of supplementary left and right side roll-yaw flaps of control set II; $M = 7.4$.

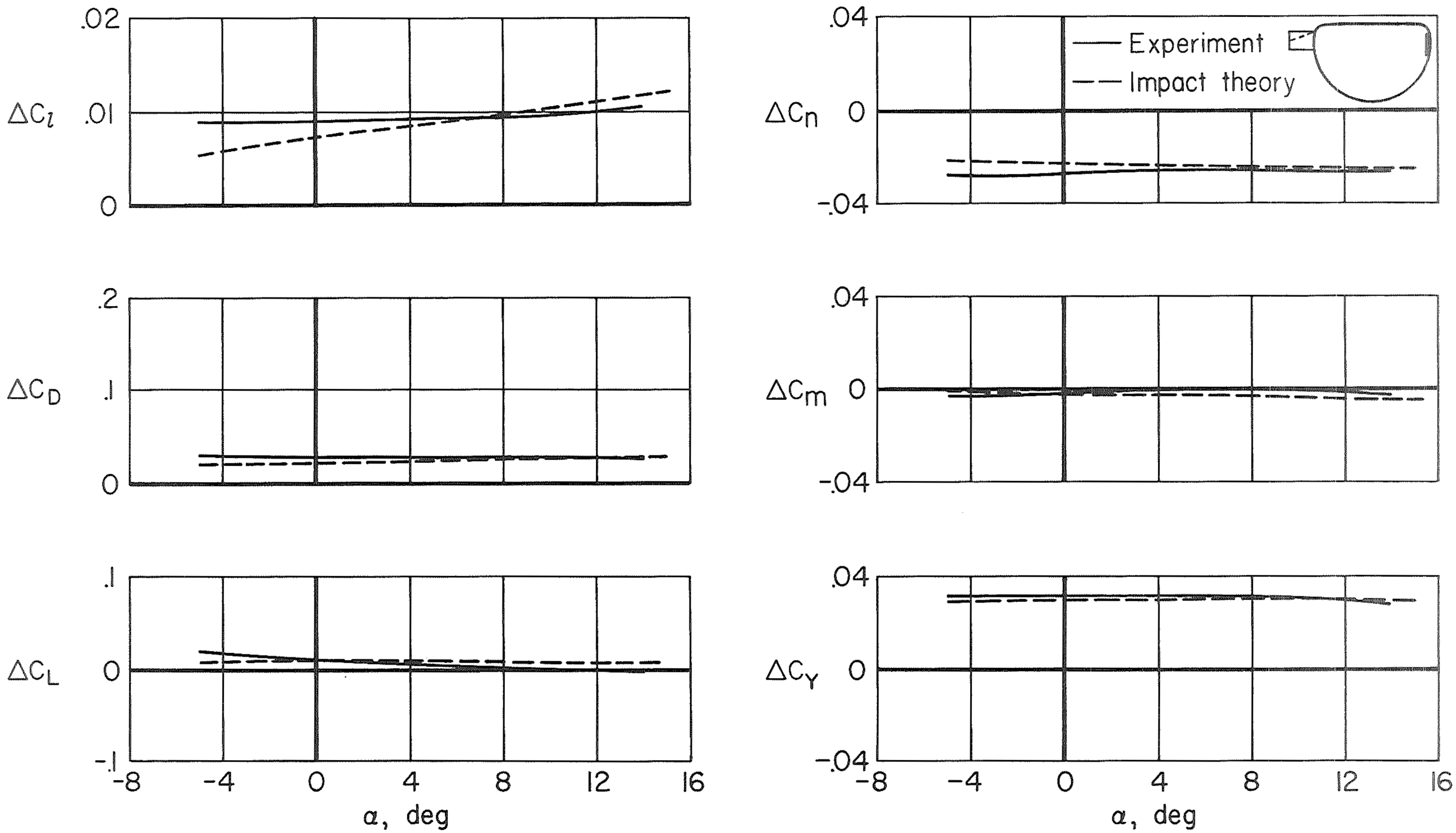


Figure 20.- Representative increments in aerodynamic coefficients due to a small deflection of the left side roll-yaw flap of control set II; $\delta_{y_L} = 30^\circ$, $\delta_{r_L} = 60^\circ$, $M = 7.4$.

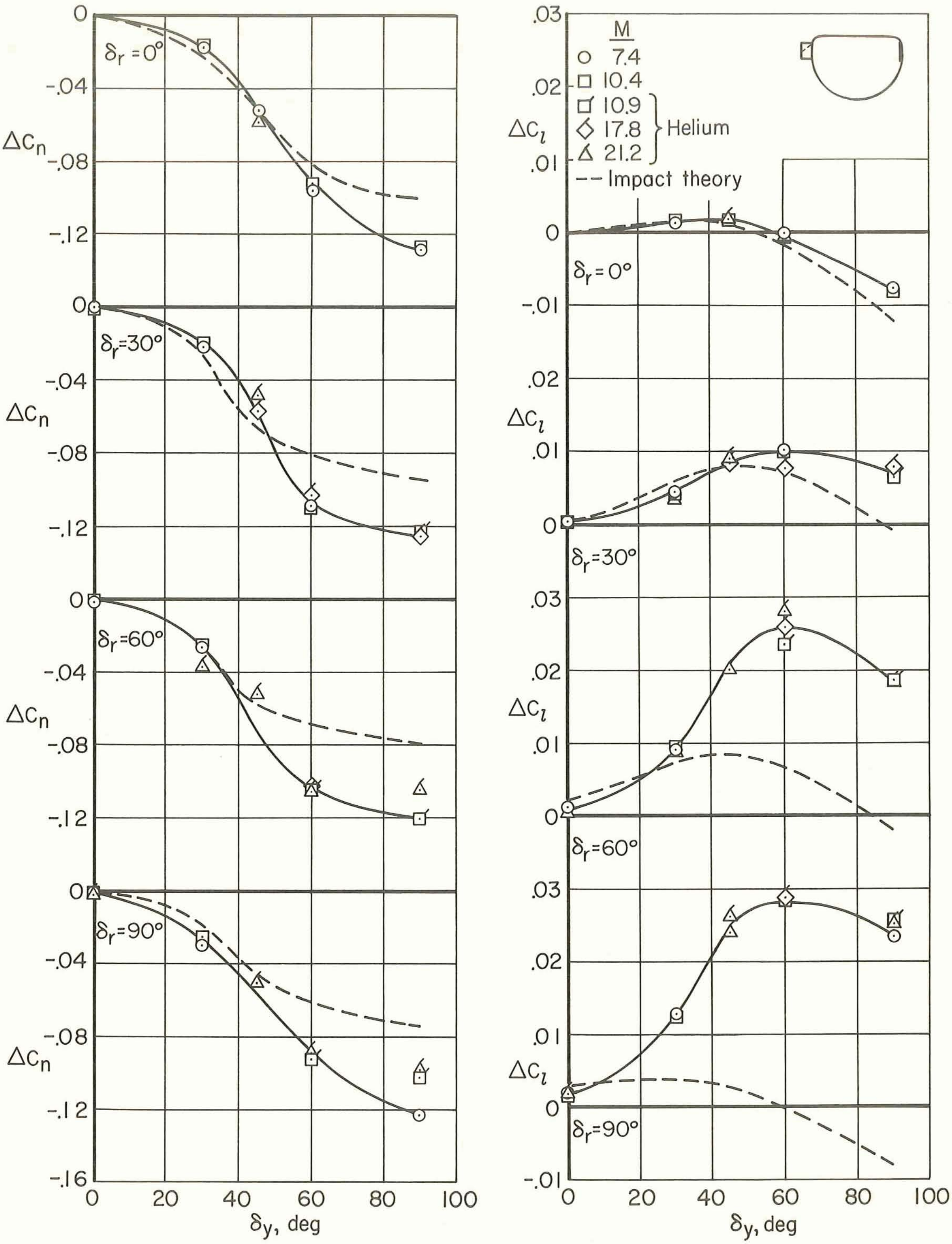
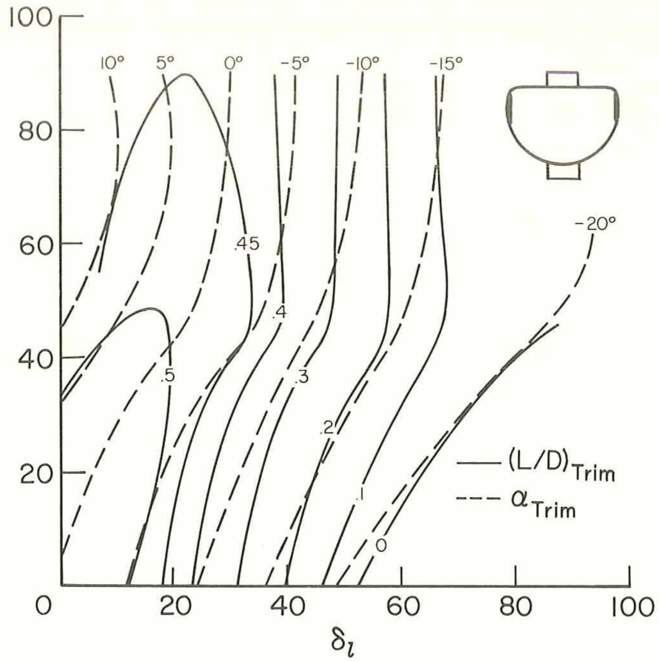
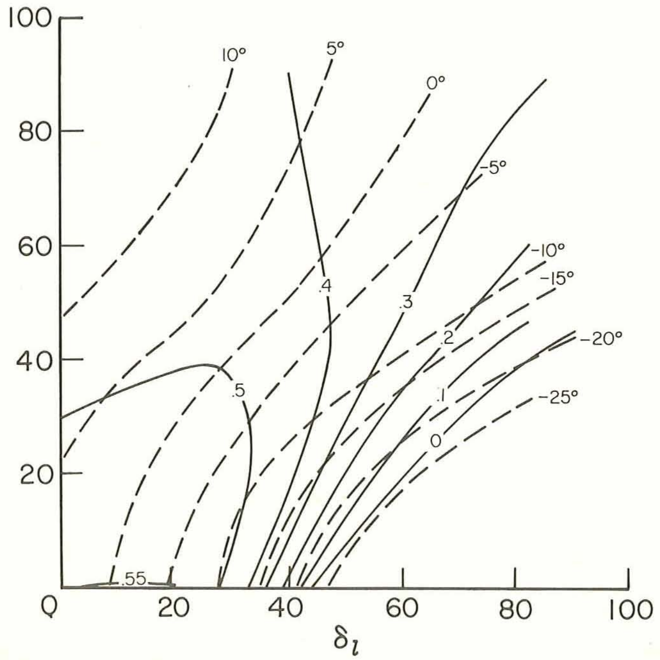


Figure 21.- Yawing- and rolling-moment-coefficient increments due to deflection of the left side roll-yaw flap of control set II at various Mach numbers; $\alpha = 0°$.



(a) Experiment, M = 7.4.



(b) Impact theory.

Figure 22.- Estimated and experimental variation of trimmed lift-drag ratios with deflection of the pitch flaps of control set II.

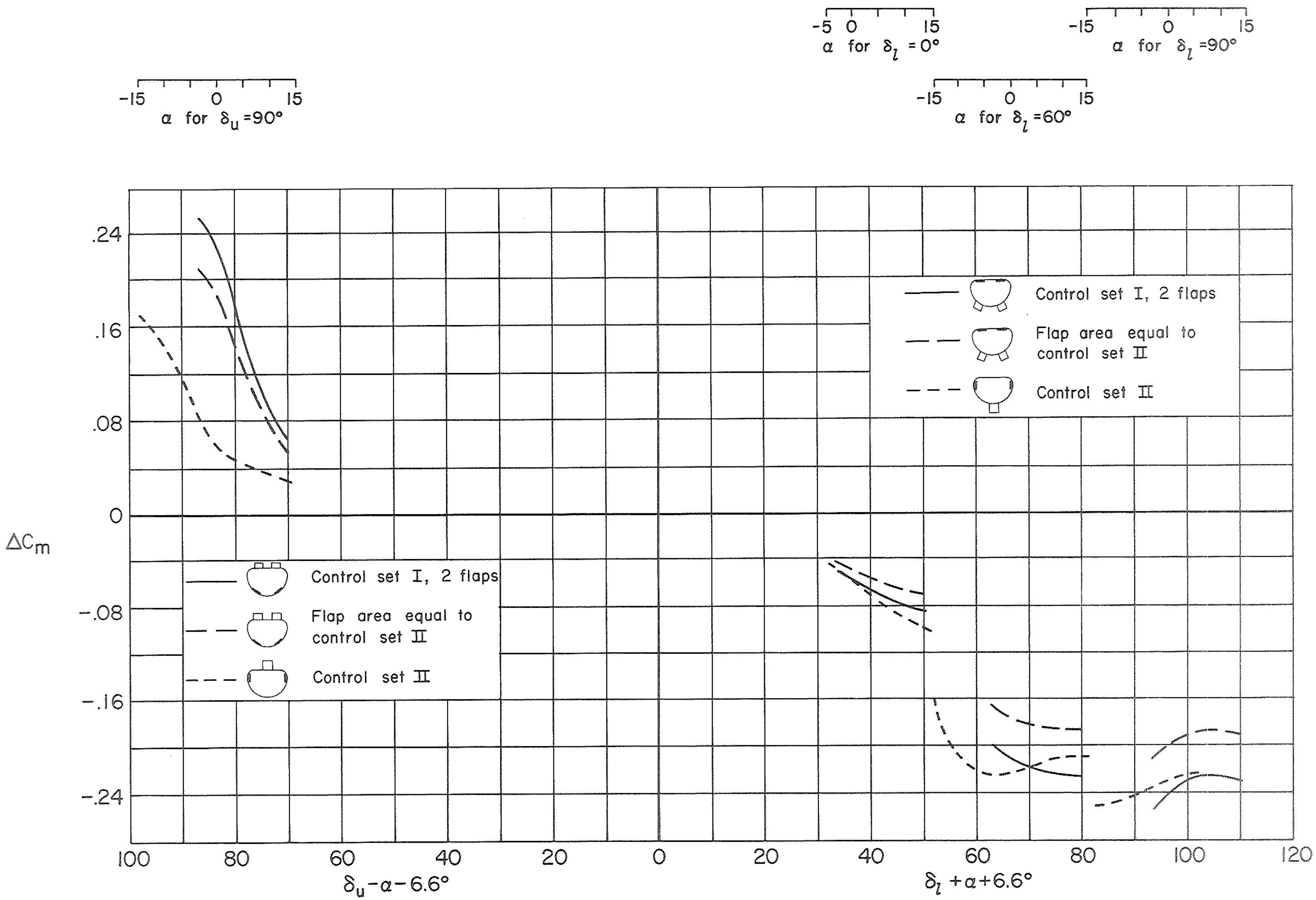


Figure 23.- Experimental moment-coefficient increments due to pitch-flap deflections of control sets I and II; M = 7.4.

[redacted]

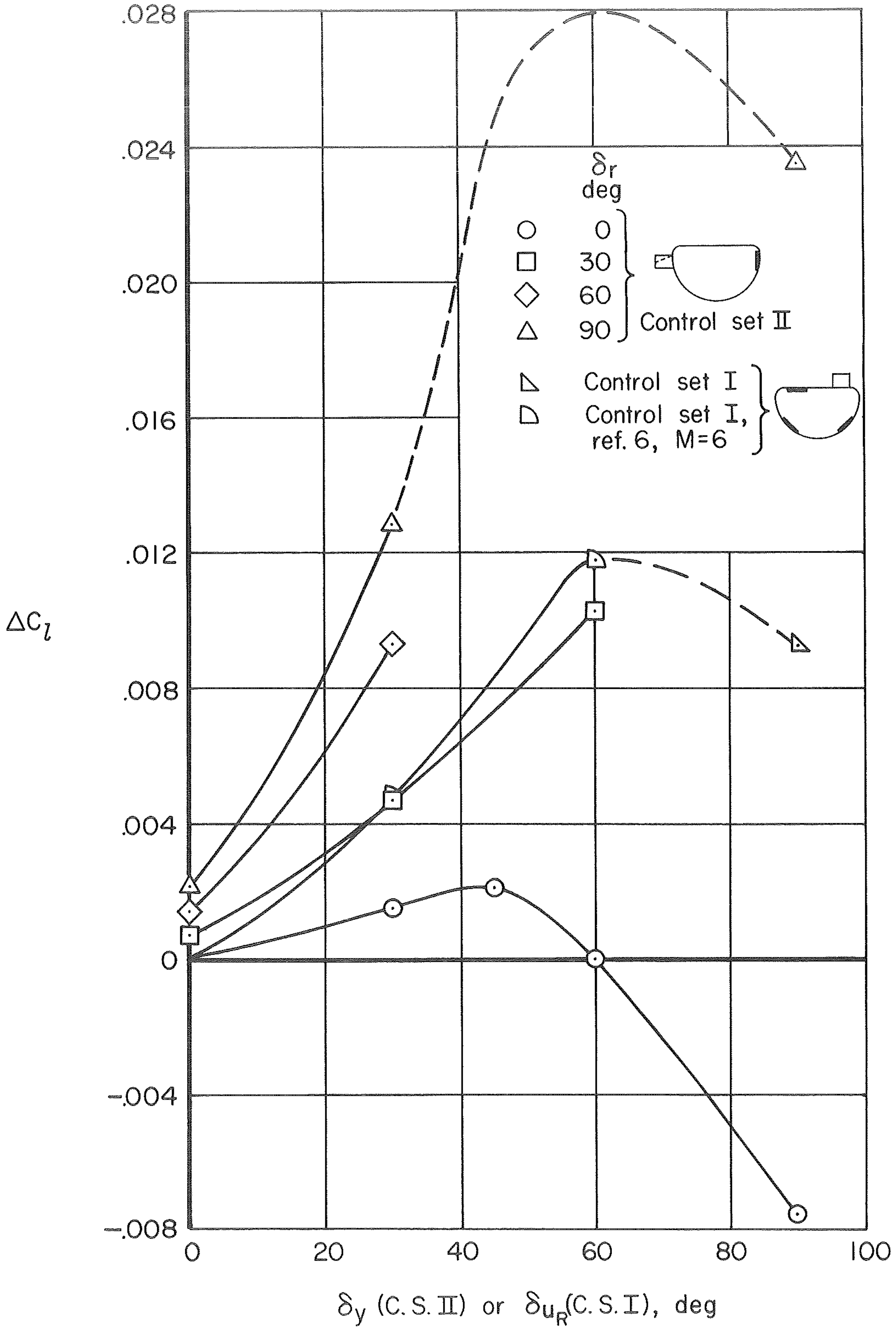


Figure 24.- Increment changes in rolling-moment coefficient due to flap deflections of control sets I and II; $\gamma = 0^{\circ}$, M = 7.4.

[redacted]

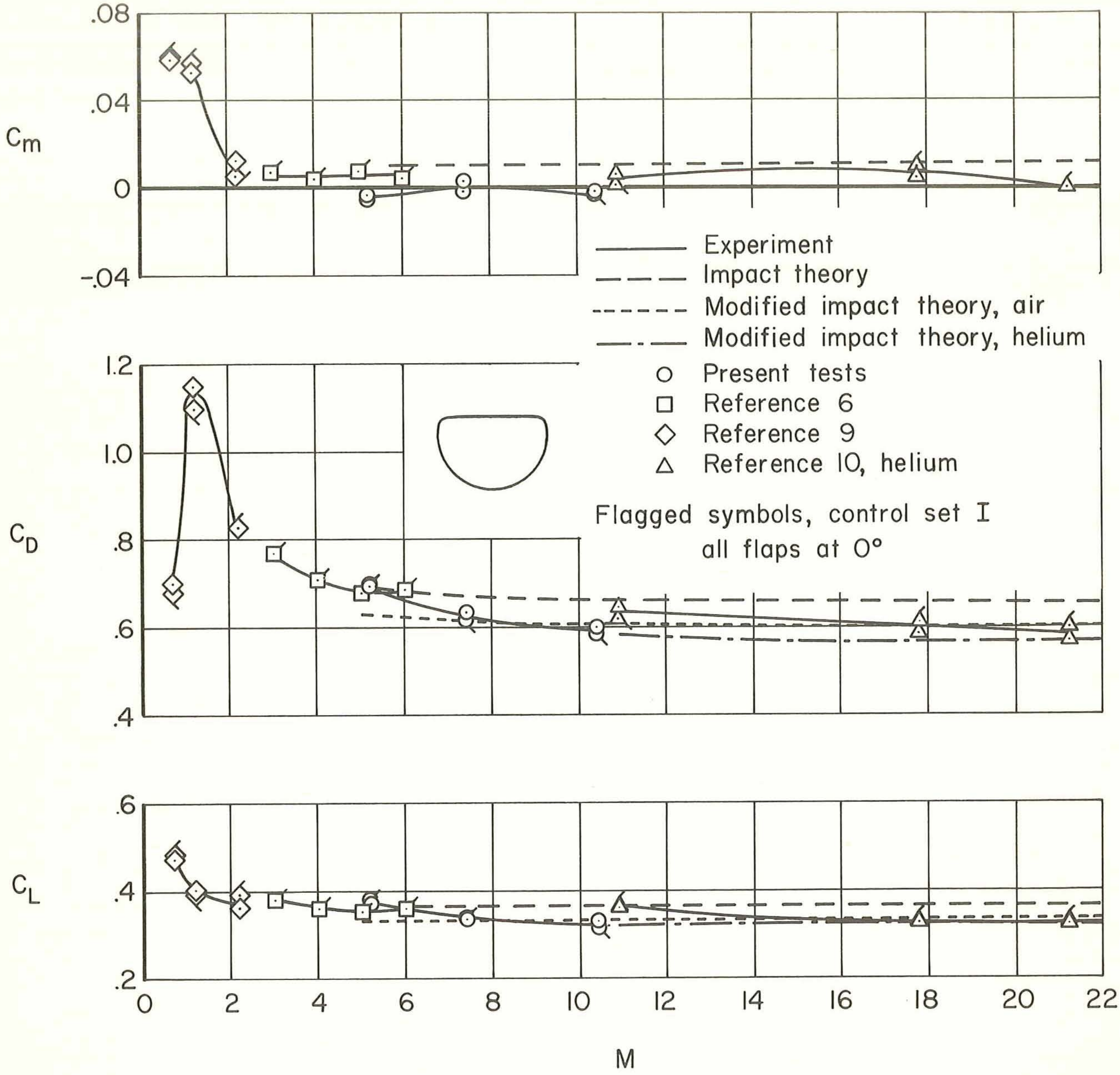


Figure 25.- Variation of the longitudinal gas-dynamic characteristics of the basic body with Mach number; $\alpha = 0^{\circ}$.

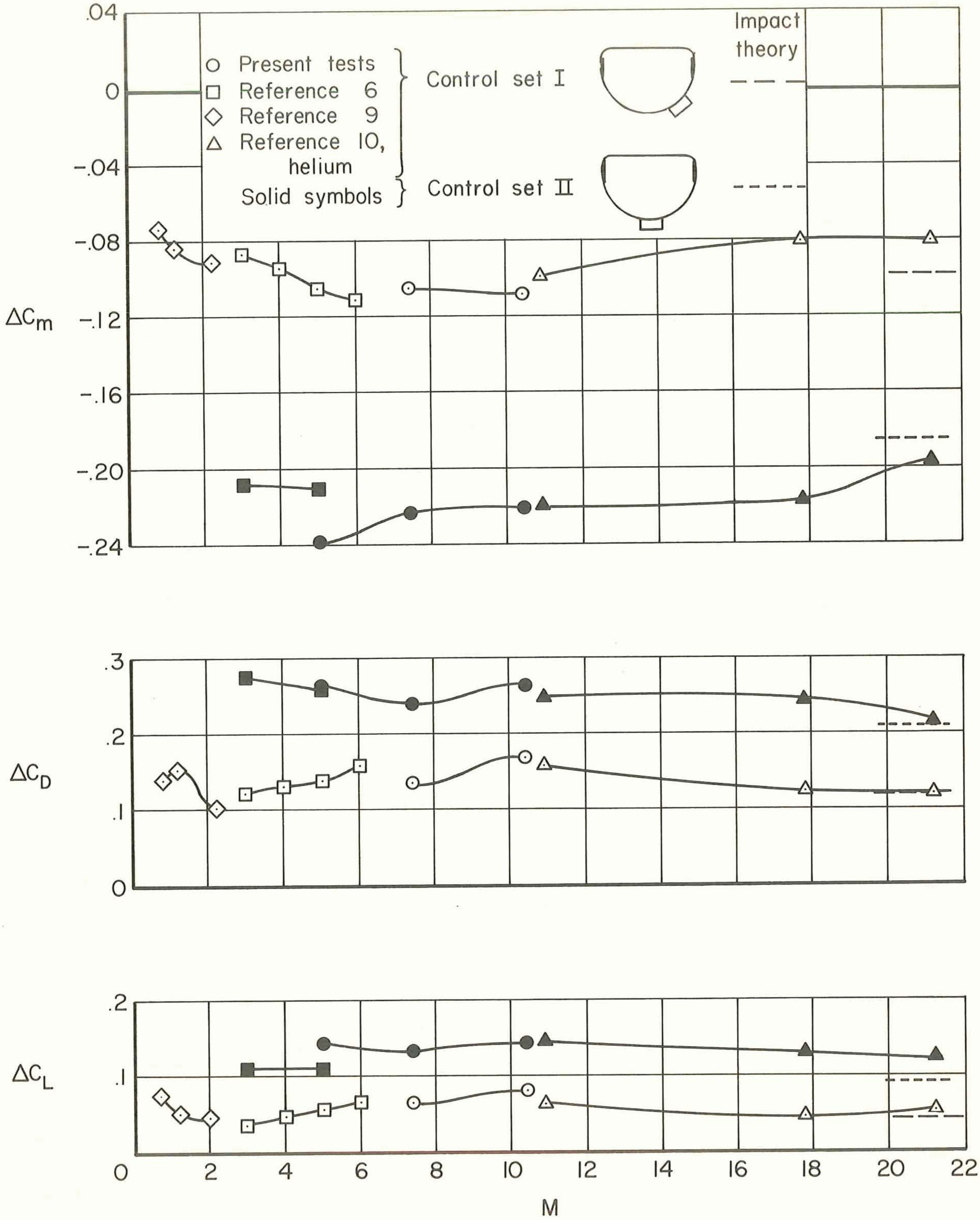


Figure 26.- Variation with Mach number of pitching-moment-, drag-, and lift-coefficient increments due to a 60° deflection of a lower flap; control sets I and II, $\gamma = 0^{\circ}$.

[redacted]

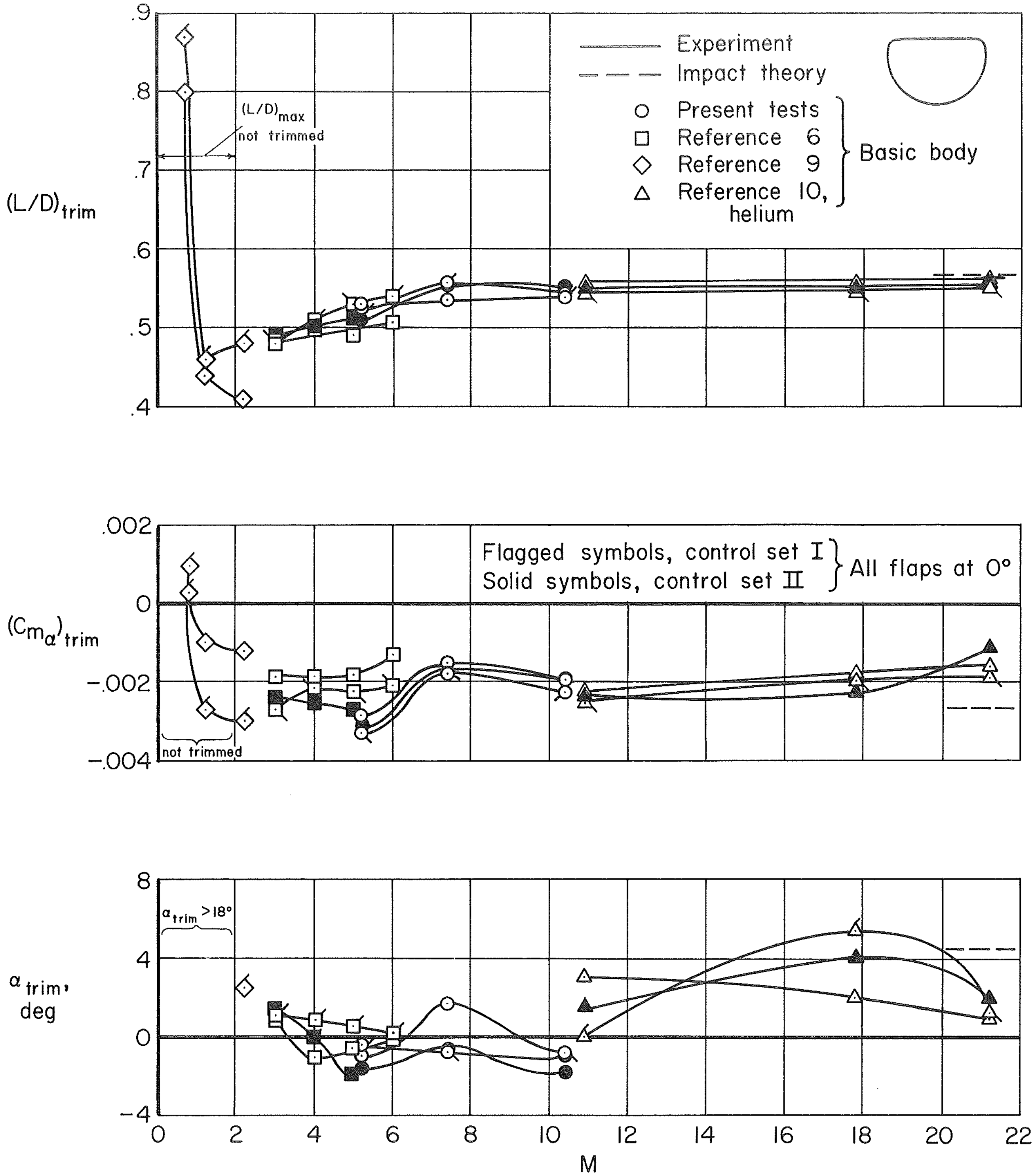


Figure 27.- Variation of trim characteristics with Mach number of the basic body and the body with flaps undeflected.

[redacted]

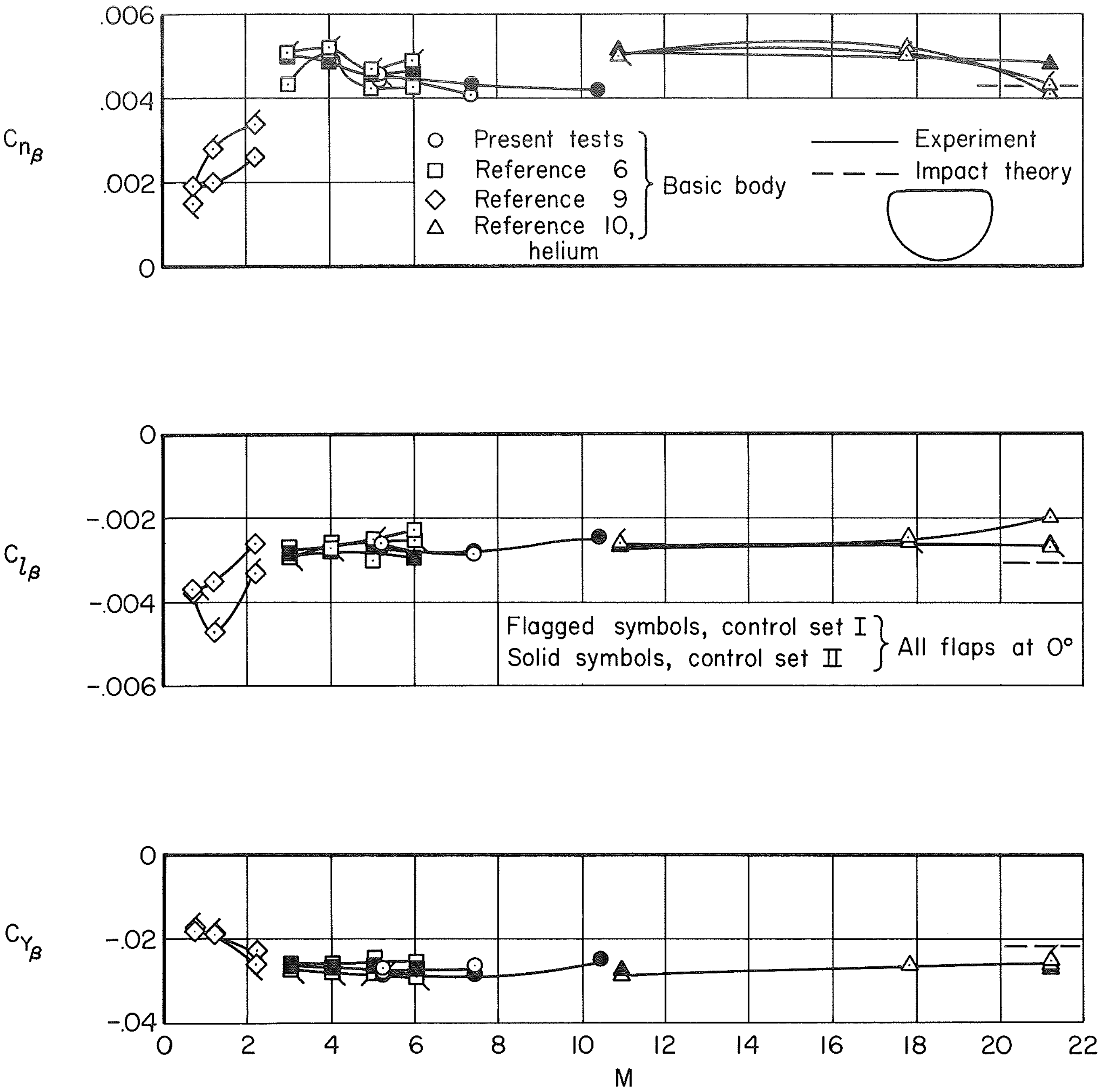
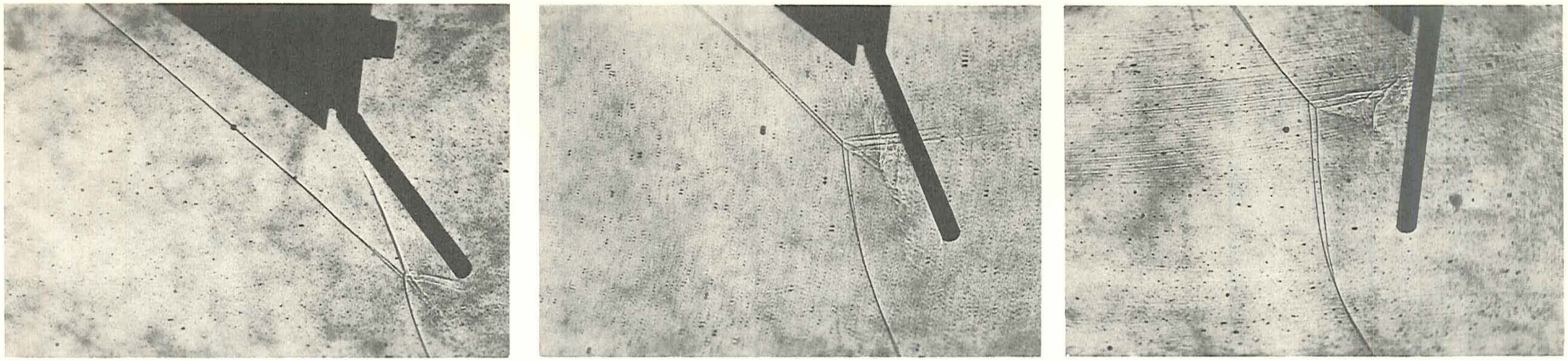


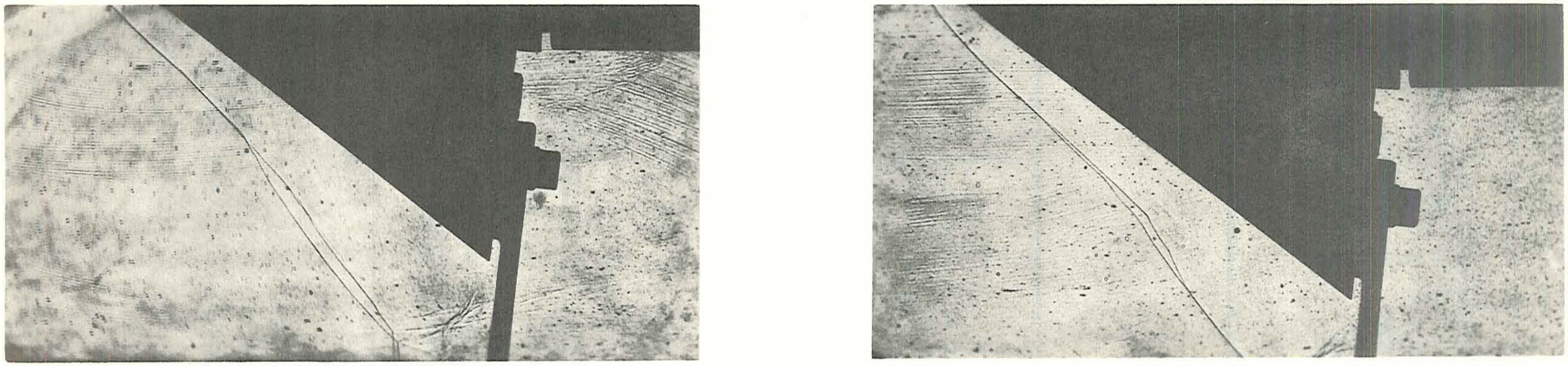
Figure 28.- Variation of the lateral-directional stability derivatives with Mach number of the basic body and the body with flaps undeflected; $\alpha = 0^{\circ}$.



A-28340

$\delta_l = 45^\circ$ $\delta_l = 60^\circ$ $\delta_l = 90^\circ$

(a) Near flaps



A-28341

(b) Near body, $\delta_l = 90^\circ$

Figure 29.- Local unsteady flow near body and lower flaps of control set II; M = 10.4.

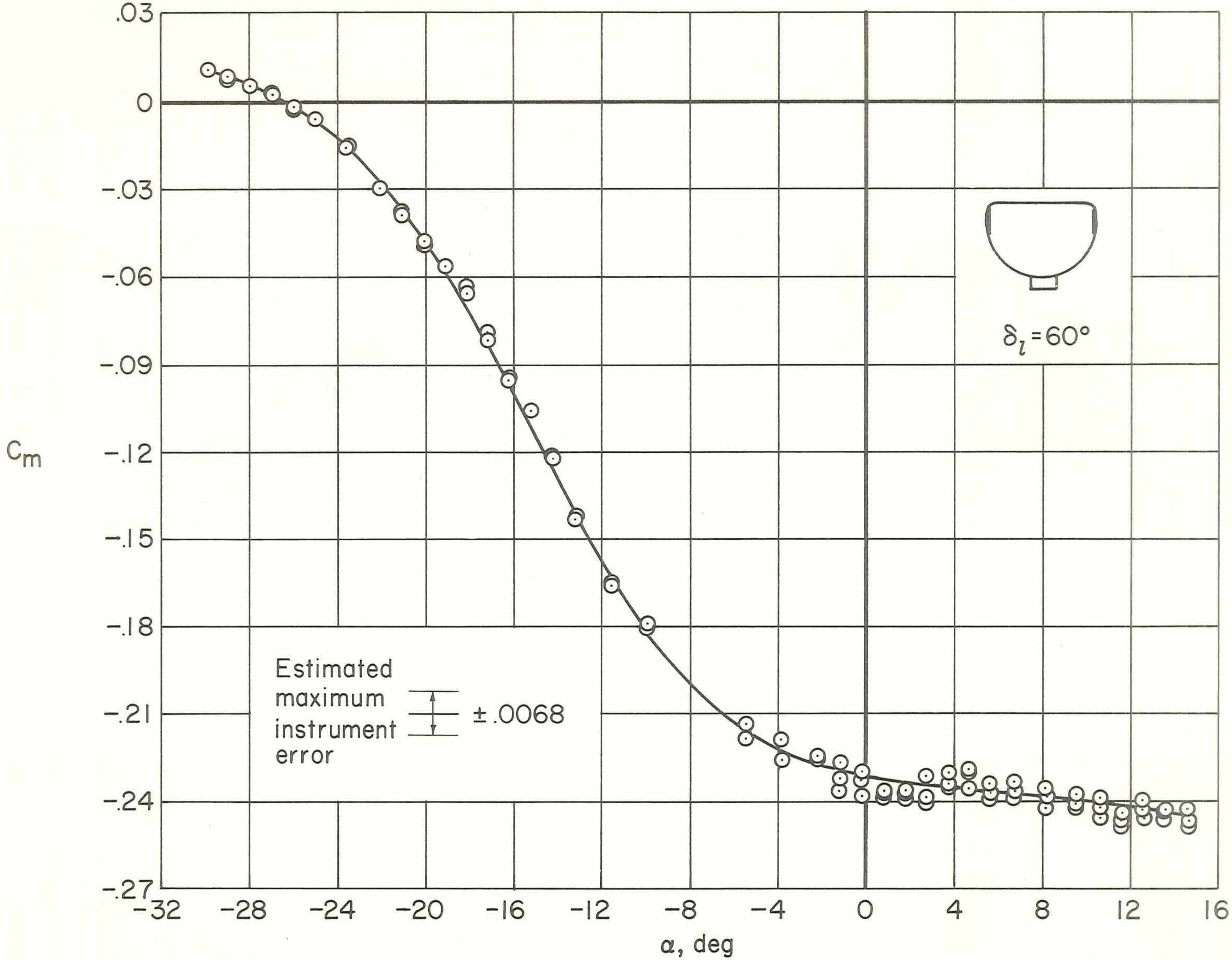
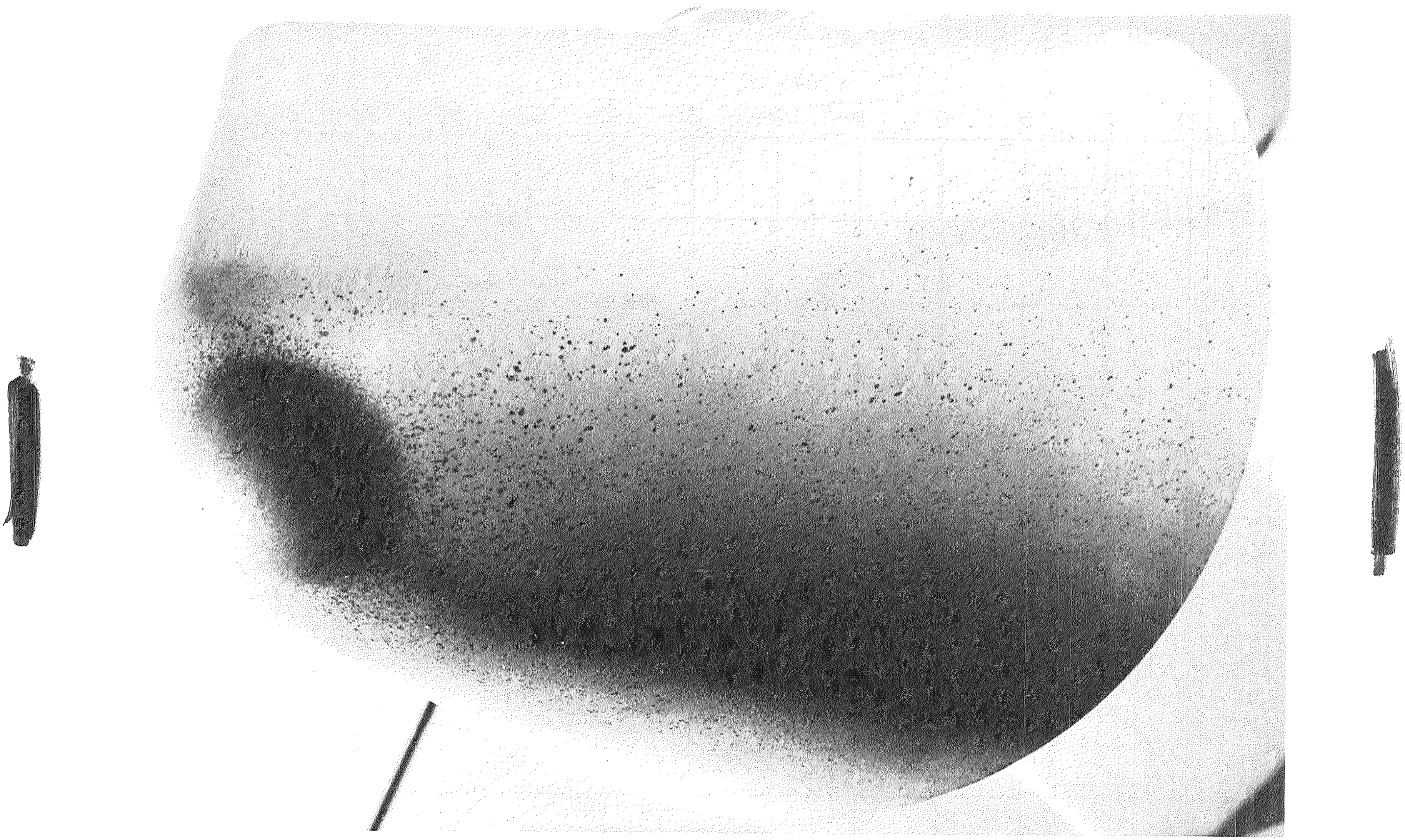
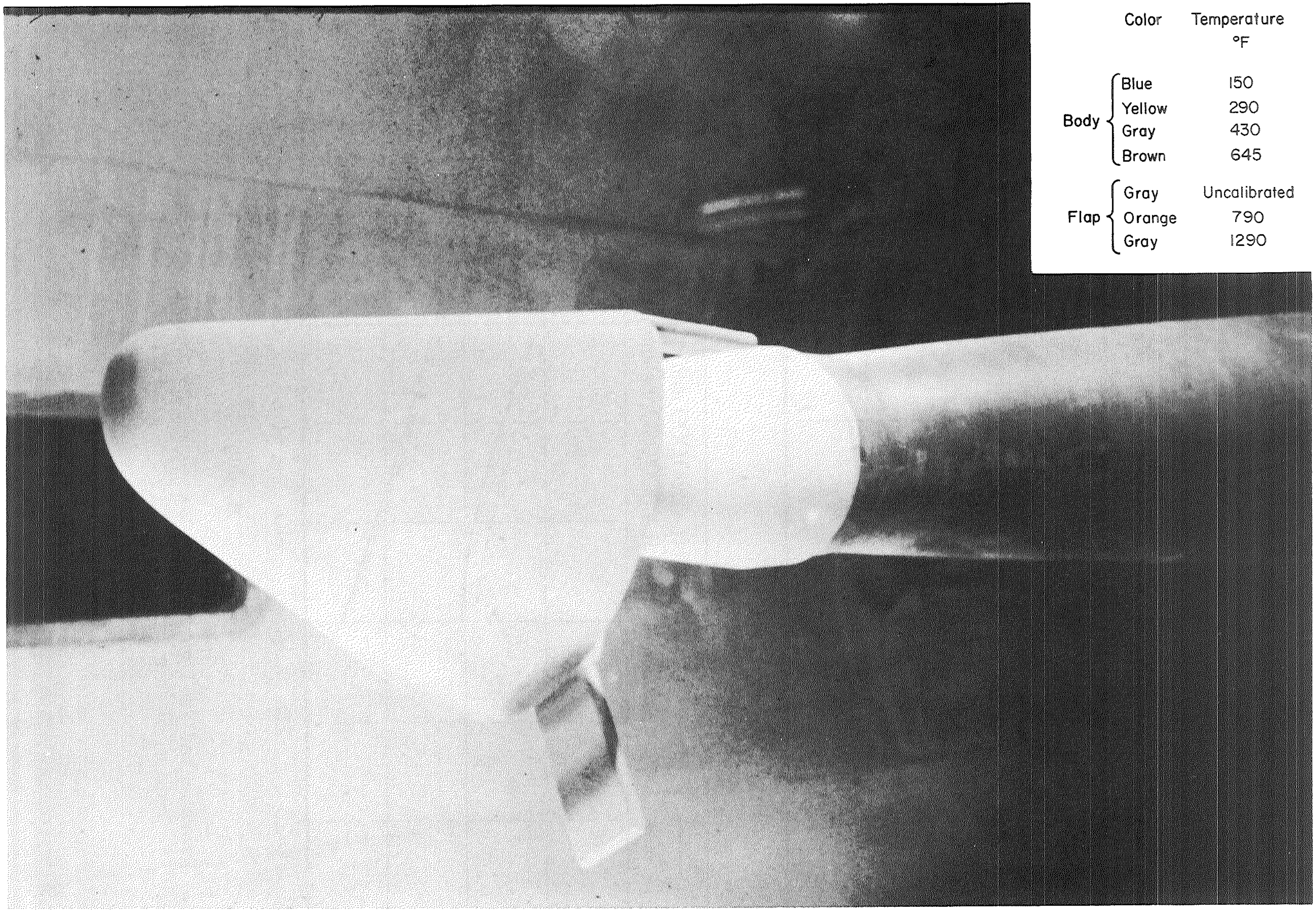


Figure 30.- Typical plot indicating an increase in scatter of pitching-moment coefficients at large flap deflections relative to the airstream; M = 10.4.



A-29870

Figure 31.- Color photograph of typical pattern over the basic body produced by temperature sensitive paint; $\alpha = -5^{\circ}$ to $+15^{\circ}$, $T_t = 1600^{\circ}$ F, and $M = 10.4$.



A-29871

Figure 32.- Color photograph of typical hot spots on body and flaps with large flap deflections as indicated by temperature sensitive paint; $\alpha = -5^\circ$ to $+15^\circ$, $T_{t_1} = 1600^\circ$ F, $M = 10.4$.

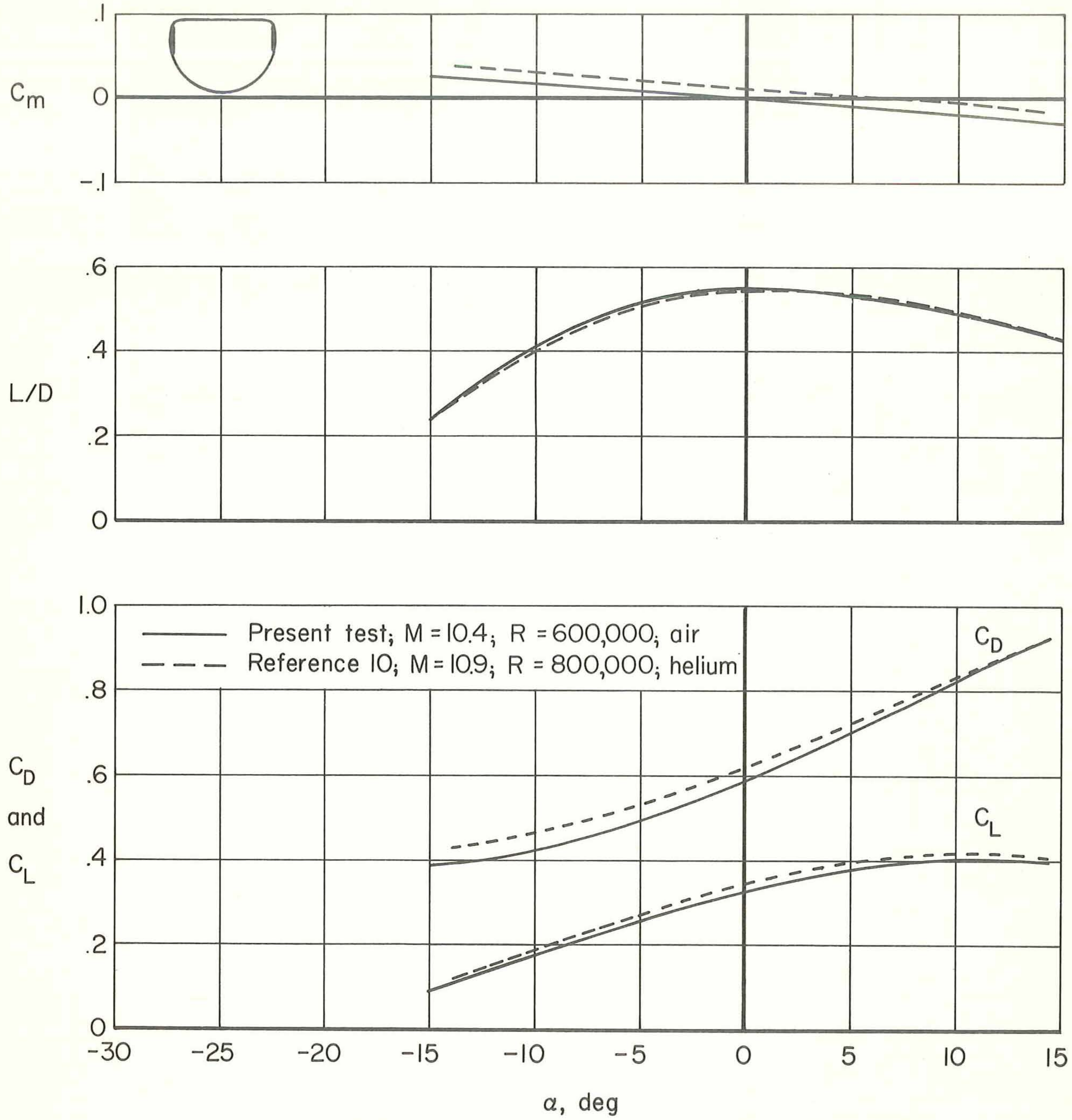


Figure 33.- Representative longitudinal gas-dynamic characteristics in air and helium of the basic body (with side flaps at 0°).

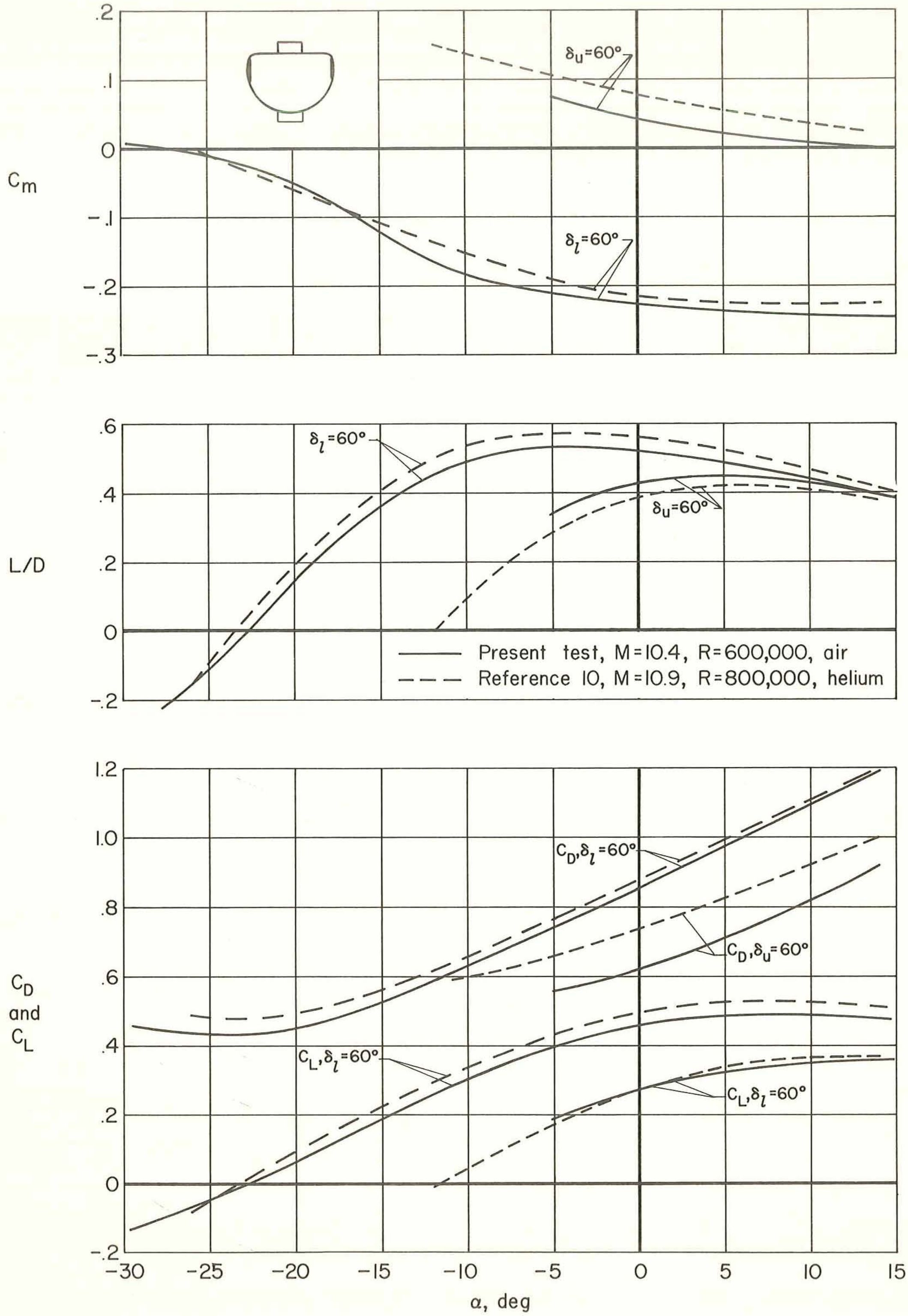


Figure 34.- Representative longitudinal gas-dynamic characteristics in air and helium of the basic body with 60° deflection of either the upper or lower pitch flap of control set II.

[redacted]

[redacted]